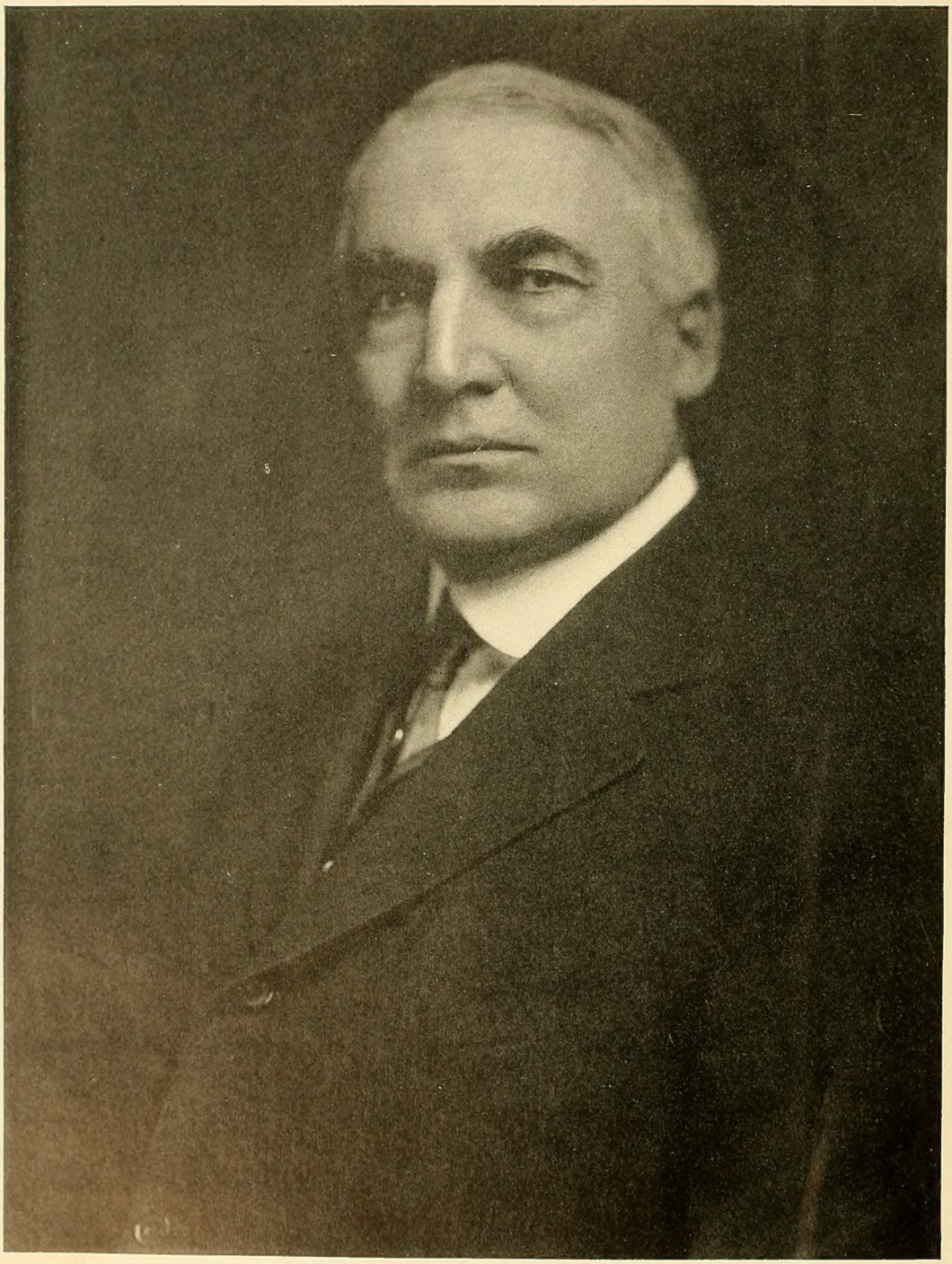
TRANSACTIONS

OF

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

1922



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Very Truly Yours
Warren G. Harding

VOL. XXX 1922

TRANSACTIONS

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OF

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

EDITED BY THE SECRETARY

PRINCIPAL OFFICE OF THE SOCIETY
ENGINEERING SOCIETIES BUILDING
29 WEST 39TH STREET, NEW YORK, N. Y., U. S. A.

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NOTICE

The Society as a body is not responsible for any statements of fact or opinion contained in the following papers and discussions, such responsibility resting entirely with those making the statements.

CONTENTS

PAGE

Index to Papers and Discussions, ... vi

List of Officers, ... vii

Articles of Incorporation, ... ix

Constitution and By-Laws, ... xi

Regulations for Benefactors and Permanent Members, ... xvii

PROCEEDINGS OF THE SPECIAL MEETING OF THE SOCIETY HELD IN NEW YORK, N. Y., MAY 19, 1922.

Introductory Proceedings and Dinner, ... 3

Paper Read, ... 15

PROCEEDINGS OF THE THIRTIETH GENERAL MEETING OF THE SOCIETY, HELD IN NEW YORK, N. Y., NOVEMBER 8 AND 9, 1922.

Introductory Proceedings, ... 37

Report of Secretary-Treasurer, ... 37

President's Address, ... 44

Election of Officers, ... 46

Election of New Members, Associates and Juniors, ... 47, 183

Transfers in Different Grades of Membership, ... 50

Second Session, Wednesday Afternoon, November 8, ... 83

Third Session, Thursday Morning, November 9, ... 119

Amendments to the Constitution and By-Laws, ... 178

Fourth Session, Thursday Afternoon, November 9, ... 183

Banquet, ... 241

Letter from President Harding, ... 243

Remarks of the Toastmaster, Mr. Walter M. McFarland, President of the Society, ... 244

Address by Hon. Edwin Denby, Secretary of the Navy, ... 245

Address by Hon. William J. Love, Vice President of the Emergency Fleet Corporation, ... 251

Address by Rear-Admiral Carl T. Vogelgesang, U. S. Navy, ... 255

Address by Brigadier General William Wiegel, U. S. Army, ... 257

Address by Mr. Homer L. Ferguson, ... 260

Obituary, ... 265

INDEX TO PAPERS AND DISCUSSIONS

MAY 19, 1922.

PAGE

OPERATING PROBLEMS OF THE AMERICAN SHIPOWNER, ... 15
By Eugene E. O'Donnell, Esq., Member.

WEDNESDAY, NOVEMBER 8, 1922.

AUTOMATIC STEERING, ... 53
By Elmer A. Sperry, E. D., Member.

DETAILS OF NAVAL DESIGN FROM JUTLAND, ... 63
By Commander Herbert S. Howard (C. C.), U. S. N., Member.

STRESSES ON VESSELS OF THE GREAT LAKES DUE TO WAVES OF VARYING LENGTHS AND HEIGHTS, ... 77
By Professor Herbert C. Sadler, Member of Council, and Professor A. Lindblad, Member.

THE APPLICATION OF DYSON'S METHOD TO PROPELLERS OF OCEAN-GOING MERCHANT LINERS, ... 85
By E. A. Stevens, Jr., Esq., Member.

A STUDY OF THE WAKE OF CERTAIN MODELS BY MEANS OF A CURRENT METER, . . 93
By Professor E. M. Bragg, Member.

SOME EXPERIMENTS ON PROPELLER POSITION AN PROPULSIVE EFFICIENCY, . . . 103
By Rear-Admiral D. W. Taylor (C. C.), U. S. N., Honorary Vice-President.

THURSDAY, NOVEMBER 9, 1922.

EFFICIENCY IN THE OPERATION OF STEAMSHIPS, ... 121
By Captain Daniel A. J. Sullivan, Member.

A 1,650 HORSE-POWER GASOLINE FIRE BOAT, ... 137
By A. D. Stevens, Esq., Member.

THE LONGITUDINAL STRENGTH OF RIGID AIRSH PS, ... 143
By Professor William Hovgaard, Member.

MACHINERY AND TRIALS OF THE PASSENGER SHIPS—AMERICAN LEGION CLASS, . . 187
By Robert Warriner, Esq., Member.

STANDARDIZATION AS AFFECTING THE SHIPBUILDING INDUSTRY IN THE UNITED STATES, 207
By E. H. Rigg, Esq., Member of Council.

SELECTION OF THE BEST KIND OF PROPELLING MACHINERY, ... 225
By J. L. Ackerson, Esq., Member.

APPENDIX, ... 237

OFFICERS OF THE SOCIETY

President.

WALTER M. McFARLAND.

Past Presidents and Permanent Members

FRANCIS T. BOWLES,
WASHINGTON L. CAPPS.
STEVENSON TAYLOR,
ROBERT M. THOMPSON.

Honorary Vice-Presidents.

FRANK E. KIRBY
WILLIAM F. DURAND
DAVID W. TAYLOR
WILLIAM J. BAXTER
JOSEPH H. LINNARD.

Vice-Presidents.

Term expires December 31, 1923:

HOMER L. FERGUSON
HENRY A. MAGOUN
FRANK L. DuBOSQUE,
WILLIAM A. DOBSON.

Term expires December 31, 1924:

LEWIS NIXON,
HUTCHINSON I. CONE,
CECIL H. PEABODY,
JOSEPH W. POWELL.

Term expires December 31, 1925:

ALBERT P. NIBLACK.
RICHARD M. WATT,
CHARLES P. WETHERBEE,
HARVEY D. GOULDER.

Members of Council.

Term expires December 31, 1923:

HERBERT C. SADLER,
DANIEL H. COX,
CHARLES F. BAILEY,
WILLIAM H. TODD,
ERNEST H. RIGG,
WILLIAM McENTEE.

Term expires December 31, 1924:

ANDREW FLETCHER,
RICHARD H. M. ROBINSON,
WILLIAM G. COXE,
J. H. MULL,
ROBERT HAIG,
CHARLES W. DYSON

Term expires December 31, 1925:

CHARLES A. McALLISTER,
THEODORE E. FERRIS,
HUGO P. FREAR,
WILLIAM L. R. EMMET,
J. HOWLAND GARDNER,
WILLIAM J. DAVIDSON.

Associate Members of Council.

Term expires December 31, 1923:

HERBERT L. ALDRICH,
HARRY H. RAYMOND.

Term expires December 31, 1924:

ERNEST M. BULL,
JOSEPH N. PEW, JR.

Term expires December 31, 1925:

ALFRED GILBERT SMITH
GEORGE D. ALI.

Executive Committee.

WALTER M. McFARLAND, *Ex-Officio.*

STEVENSON TAYLOR,
WASHINGTON L. CAPPS,
ANDREW FLETCHER,
FRANK L. DuBOSQUE,
ALFRED GILBERT SMITH.
JOSEPH W. POWELL,
HOMER L. FERGUSON,

Secretary-Treasurer.

DANIEL H. COX.

Assistant Secretary-Treasurer.

THOMAS J. KAIN.

ARTICLES OF INCORPORATION

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

STATE OF NEW YORK,
CITY AND COUNTY OF NEW YORK. }

We, the subscribers, WM. H. WEBB, CHAS. H. CRAMP, GEORGE E. WEED, H. TAYLOR GAUSE, WILLIAM T. SAMPSON, HORACE SEE, FRANK L. FERNALD, FRANCIS T. BOWLES, WASHINGTON L. CAPPS, EDWIN D. MORGAN, GEORGE W. QUINTARD, HARRINGTON PUTNAM and JACOB W. MILLER, being persons of full age and citizens of the United States, of whom a majority—namely, William H. Webb, George E. Weed, Horace See, Edwin D. Morgan, George W. Quintard, Harrington Putnam, Frank L. Fernald, and Jacob W. Miller are citizens of and residents of and within this State, desiring to associate ourselves for scientific purposes under, and pursuant to, an Act of the State of New York, providing for the incorporation of benevolent, charitable, scientific, and missionary societies, passed April 12, 1848, and the several acts amending or supplementing the same, do hereby, in accordance with the requirements thereof, certify as follows:—

First. The name or title by which the Society shall be known in law is THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

Second. The particular business and objects of such Society are the promotion of practical and scientific knowledge in the arts of shipbuilding and marine engineering and the allied professions, and in furtherance of this object, to hold meetings for social intercourse among its members, and the reading and discussion of professional papers, and to circulate by means of publication the knowledge thus obtained.

Third. The number of directors, trustees, or managers to manage the Society shall be seven, and shall consist of a President, a Secretary, and five Members of Council.

Fourth. The names of the trustees, directors, or managers of the Society for the first year of its existence are:—President, Clement A. Griscom; Secretary, Washington L. Capps; Members of Council, Francis T. Bowles, H. Taylor Gause, Chas. H. Loring, Lewis Nixon, Harrington Putnam.

Fifth. The business of the Society is to be conducted, and its place of business and principal office is to be located, in the City and County of New York.

IN WITNESS WHEREOF we have made, signed, and acknowledged this Certificate, this 28th day of April, 1893.

WILLIAM H. WEBB.
CHAS. H. CRAMP.
H. T. GAUSE.
GEORGE E. WEED.
W. T. SAMPSON.
HORACE SEE.
F. L. FERNALD.
FRANCIS T. BOWLES.
W. L. CAPPS.
E. D. MORGAN.
GEORGE W. QUINTARD.
HARRINGTON PUTNAM.
J. W. MILLER.

CITY AND COUNTY OF NEW YORK, *ss:*

On this 28th day of April, 1893, before me personally appeared William H. Webb, Charles H. Cramp, H. Taylor Gause, George E. Weed, William T. Sampson, Horace See, Frank L. Fernald, Francis T. Bowles, Washington L. Capps, and Edwin D. Morgan, to me known and known to me to be the persons described in and who executed the foregoing certificate, and severally acknowledged to me that they executed the same.

JAMES FORRESTER,
Notary Public, Kings Co., Cert. N. Y. Co.

CITY AND COUNTY OF NEW YORK, *ss:*

On this 1st day of May, 1893, before me personally appeared George W. Quintard and Harrington Putnam, to me known and known to me to be the individuals described in and who executed the foregoing certificate, and they severally acknowledged to me that they executed the same.

JAMES FORRESTER,
Notary Public, Kings Co., Cert. N. Y. Co.

CITY AND COUNTY OF NEW YORK, *ss:*

On this 9th day of May, 1893, before me personally appeared Jacob W. Miller, to me known and known to me to be one of the individuals described in and who executed the foregoing certificate, and he duly acknowledged to me that he executed the same.

JAMES FORRESTER,
Notary Public, Kings Co., Cert. N. Y. Co.

(ENDORSED.)

Upon reading the within Certificate for the Incorporation of the Society of Naval Architects and Marine Engineers, I hereby approve and consent to the incorporation thereof and the within Certificate and filing thereof, and direct that the same be filed in the office of the Clerk of the City and County of New York.

Dated New York, May 10, 1893.

EDWD. PATTERSON,
Justice of the Supreme Court in the State of New York
in and for the City and County of New York.

CONSTITUTION AND BY-LAWS OF THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

(As amended November 9, 1922.)

Article I.

Name and Object.

1. The name of the Association shall be "The Society of Naval Architects and Marine Engineers."

2. Its object shall be the promotion of the art and science of shipbuilding, commercial and naval, in the United States of America.

3. In furtherance of this object, annual meetings shall be held for the reading and discussion of appropriate papers and interchange of professional ideas, thus making it possible to combine the results of experience and research on the part of shipbuilders, marine engineers, naval officers, yachtsmen, and those skilled in producing the material from which ships are built and equipped.

Article II.

Membership.

1. The Society shall consist of Members, Associates, Juniors, Honorary Members and Honorary Associates.

2. *Members.*—(1) The class of Members shall consist exclusively of Naval Architects, Marine and Mechanical Engineers, including Professors of Naval Architecture or Mechanical Engineering in colleges of established reputation.

(2) A Candidate for this class must not be less than twenty-eight years of age and comply with the following regulations: He shall submit to the Council a statement showing that he has been engaged in the practice of his profession, in a responsible capacity, for at least five years, and setting forth the grounds upon which he bases his claim to membership. This statement shall be signed by three Members, who shall certify to their personal knowledge of the candidate and approval of his statement.

(3) In the case of persons not American citizens, the signatures of three Members shall be required in confirmation of their personal knowledge of the candidate's scientific attainments.

(4) If three-fourths of the members of the Council present are in favor of the admission of the candidate, his name shall be submitted to the Members of the Society at the next meeting; the voting to be by ballot, should a ballot be demanded.

3. *Associates.*—(1) The class of Associates shall consist of persons who, by profession, occupation, or scientific attainments, are qualified to discuss the qualities of a ship.

(2) Candidates for this class shall submit to the Council a written statement of their qualifications for membership; this shall be signed by two Members or Associates who shall certify to their personal knowledge of the candidate and approval of his statement. If considered by three-fourths of the Council present duly qualified for associate membership their names shall be submitted to the Society at the next meeting, to be voted upon by the Members and Associates; the voting to be by ballot, should a ballot be demanded.

4. The proportion of favorable votes for deciding the election of Members and Associates shall be at least four-fifths of the number recorded.

5. *Juniors.*—(1) The class of Juniors shall consist of graduates of technical schools of established reputation, or persons who have had not less than two years' practical experience in marine engine works or shipyards.

(2) Candidates must be at least eighteen years of age and certify their intention to continue in the profession and become naval architects or marine engineers.

(3) Juniors shall be eligible for transfer to the class of Members or Associates after fulfilling the necessary conditions; when they are twenty-eight years of age they shall be offered the option of being transferred to the class of Members or Associates in conformity with their qualifications; but if they do not accept such offer or do not qualify, they shall be dropped from the rolls of the Society.

(4) The admission of Juniors shall be by a favorable vote of three-fourths of the members of the Council present.

(5) Juniors shall have no voice in the government of the Society or admission of members.

6. *Honorary Members and Honorary Associates.*—The Council may elect Honorary Members and Honorary Associates, the total number not to exceed twenty-five. They shall be persons of acknowledged eminence in their profession upon whom the Council may see fit to confer an honorary distinction.

7. *Benefactors and Permanent Members.*—The Council may establish a list of Benefactors. It may also elect as Permanent Members of the Society such Members or Associate Members as shall, in the opinion of the Council, by reason of notably liberal contributions to the Society, merit special recognition. Permanent Members shall, from the date of their election, be relieved from annual dues, and shall have the right, subject to the approval of Council, to designate, by will or otherwise, their successors. The conditions to be met before placing any name on the list of Benefactors and the regulations governing the election of Permanent Members shall be prescribed by the Council.

Article III.

Dues, Suspension and Expulsion of Members.

1. The entrance fees, payable on admission to the Society, shall be as follows:

Members and Associates, fifteen dollars; Juniors, ten dollars; Honorary Members and Honorary Associates, no fees.

2. The annual dues shall be as follows:

Members and Associates, fifteen dollars; Juniors, ten dollars; Honorary Members and Honorary Associates, no dues.

3. A member transferred from one grade to another shall pay the difference between the entrance fees of the two grades, and his annual dues shall be those of the grade to which transferred.

4. The annual dues shall be payable in advance on the first day of January. The Secretary shall notify each member of the amount due for the ensuing year at the time of giving notice for the annual meeting. On notification of his election each member shall pay his entrance fee. If he desires to receive the published transactions of the Society for the meeting at which he is elected, he shall pay ten dollars in addition to the entrance fee.

5. Members and Associates can compound for all future dues and become Life Members or Life Associates by making a single payment of three hundred dollars and signing an agreement to conform to any future amendments to the Constitution and By-Laws.

6. Members are entitled to no return of fees upon severing their connection with the Society.

7. Any member whose dues are more than three months in arrears shall be notified by the Secretary. Should his dues become six months in arrears he shall be again notified by the Secretary and his rights as a member suspended. Should his dues become one year in arrears the delinquent member shall forfeit his membership in the Society unless the Council may deem it expedient to extend the time of payment.

8. The Council may, in its discretion, temporarily suspend the annual payment of dues by any member whose circumstances have become such as to make such payment impossible, and may, under similar circumstances, remit the whole or part of dues in arrears.

9. No name shall be entered on the rolls as Member, Associate or Junior, nor shall the privilege of membership be enjoyed until the payments required in paragraphs 1 to 4 of this article have been made; if the payment be delayed for more than six months from the date of election, the same shall be void unless the Council otherwise direct.

10. (1) Should the expulsion of any member be judged expedient by five or more members, they must draw up and sign a proposal requesting such expulsion, delivering the same to the Secretary, to be laid before the Council.

(2) If the Council do not find reason to concur in the proposal, no entry thereof shall appear in the minutes, nor shall any public discussion thereon be permitted.

(3) If, however, the Council find the charges contained in the proposal for expulsion substantiated, the accused member shall be notified and given an opportunity to resign. If he avails himself of this privilege, no entry shall be made on the minutes nor public discussion of the case be permitted. But if he declines to resign and offers no satisfactory explanation of the charge, the whole case shall be submitted to a special meeting of the Society.

(4) If two-thirds of the members at this special meeting (providing there be not less than twenty present) vote for expulsion, the Chairman of the meeting shall cause the accused to be expelled from the Society and direct the Secretary to notify the accused of this action.

Article IV.

Council.

1. There shall be a Council, composed of eighteen Members and nine Associates; and the President, Past President, Honorary Vice-Presidents and Vice-Presidents shall also be *ex-officio* Council Members.

2. The Council shall meet at the call of the President just prior to the Annual General Meeting of the Society and at such other times as the interests of the Society may demand.

3. At all meetings of the Council eight Members thereof shall constitute a quorum.

4. The term of office of Council Members shall be three years.

5. (*a*) Prior to September first of each year the Executive Committee shall prepare ballots for filling the places of the retiring Council Members. The ballots shall contain the names of six Members and three Associates of the Society and shall be mailed as soon as practicable after September first of each year to all Members and Associates.

(*b*) An independent nomination for Council Members may be made in writing by not less than thirty Members and Associates, of which number at least two-thirds must be Members; and if such nomination is received by the Secretary prior to September fifteenth ballots shall then be prepared by him, containing the names of those thus nominated, and these ballots shall also be mailed to the membership.

(*c*) Each Member may vote for not more than six Members and three Associates, and each Associate may vote for not more than three Associates to be Council Members.

The ballots shall be returned to the Secretary and canvassed by the Council at its meeting just prior to the Annual General Meeting of the Society; and the six Members of the Society and the three Associates receiving the highest number of votes shall be declared elected Council Members.

(*d*) A vacancy in the office of Council Member shall be filled by the Council for the unexpired term.

Article V.

Officers.

1. The officers of the Society shall consist of a President, Past Presidents, Honorary Vice-Presidents, twelve Vice-Presidents and a Secretary and Treasurer.

2. Only Members and Associates of the Society are eligible for the office of President, Honorary Vice-President or Vice-President.

3. (*a*) At its meeting just prior to the Annual General Meeting of the Society held in the year with which the term of the President expires, the Council shall nominate a candidate for the office of President whose name shall be presented to the Society at the said annual meeting.

(*b*) The nomination of any other candidate signed by at least sixty Members and Associates, of which number at least two-thirds must be Members, and submitted to the Secretary prior to the annual meeting, shall also be presented.

(*c*) The candidate receiving the highest number of votes shall be President for the ensuing three years.

(*d*) A vacancy in the office of President shall be filled by ballot by the Council from the list of Past Presidents, Honorary Vice-Presidents and Vice-Presidents, until the end of the year in which the vacancy occurs, and at the Annual General Meeting of that year a new President shall be elected for three years in the manner prescribed in the preceding paragraphs.

(*e*) The President shall not be eligible for election as his own successor.

4. Honorary Vice-Presidents may be chosen from the list of Vice-Presidents or from the list of Council Members who have had at least twelve years' service. They shall be chosen at the meeting of the Council next prior to the Annual General Meeting of the Society and shall be the unanimous choice of all Council Members present.

Not more than two Honorary Vice-Presidents may be elected in any one year.

5. The Vice-Presidents to fill the vacancies occurring each year shall be elected by the Council from its own membership. Retiring Vice-Presidents shall be eligible for re-election. The term of office of the Vice-Presidents shall be three years.

6. The Secretary and Treasurer must be a member of the Society and shall be elected annually by the Council, but may be removed for cause at any time by a majority vote of the Council after due notice has been given.

Article VI.

Management.

1. (1) The President shall have general supervision over the affairs of the Society, appoint special committees, and preside at the annual general meetings. He shall be *ex-officio* member of all committees.

(2) In the absence of the President, one of the Past Presidents, Honorary Vice-Presidents or Vice-Presidents, in the order of seniority as determined by original accession to, or election in, their respective grades, shall preside and perform all the duties of the President; where there is the same date of seniority, the alphabetical order will govern. Provided, however, that for the annual meeting of the Society or for any other special occasion when it is known that the President cannot attend and preside, the Executive Committee shall, in its discretion, select and designate as Acting President any one of the Past Presidents, Honorary Vice-Presidents, Vice-Presidents or members of Council, who shall act for the President in his temporary absence and shall perform all the duties which would devolve upon that officer during such annual meeting or on such special occasion.

2. (1) The direct management of the Society shall be vested in an Executive Committee of nine, composed of seven members of Council, elected annually by the Council, and the President and the Secretary of the Society *ex-officio*. At least five of the seven elective members of the committee shall be Members of the Society.

(2) Meetings of the Executive Committee may be held at any time, subject to the call of the Chairman; and four members shall constitute a quorum for the transaction of any business that may be properly brought before the committee.

3. The Excutive Committee shall manage the affairs of the Society in conformity with the laws under which it is incorporated and the provisions of this Constitution. It shall direct the investment and care of the funds of the Society; make appropriations for specific purposes; arrange for the reading and publication of professional papers; take measures to advance the interests of the Society, and generally direct its affairs under such regulations as the Council may from time to time prescribe.

4. The Executive Committee shall make an annual report to the Society, transmitting the report of the Secretary and Treasurer, and of any special committee which may have been ordered.

5. (1) The Secretary shall be the Executive Officer of the Society under the immediate direction of the President and the Executive Committee.

(2) He shall prepare the business for the annual meetings and record the proceedings thereof.

(3) He shall be responsible for all expenditures and certify the accuracy of all bills or vouchers upon which money has been paid, and he shall conduct the correspondence of the Society and keep full records of the same.

6. The Treasurer shall see that all money due the Society is collected and carefully invested in such manner as the Executive Committee may direct. If considered advisable by the Council, the duties of the Treasurer may be performed by the Secretary.

7. The accounts of the Secretary and Treasurer shall be audited annually in such manner as the Executive Committee may direct.

Article VII.

Meetings.

1. There shall be at least one annual general meeting of the Society for the reading and discussion of professional papers, election of officers for the ensuing year, and transaction of such other business as may be brought before it. The time and location of this meeting shall be determined by the Council at least three months prior to the date fixed.

2. Special meetings may be called by the Executive Committee at the request of twenty members, which request shall state the purpose of the meeting. The call for such meetings shall be issued ten days in advance, and shall state the purpose thereof. At these meetings thirty members shall constitute a quorum.

3. The Society may adopt, from time to time, such rules as it may think proper for the order of business at its meetings.

Article VIII.

Regulations and By-Laws.

1. The Council shall have authority to establish such by-laws and regulations as may be necessary for the government of the Society in the conduct of its affairs, provided that such by-laws and regulations do not conflict with the provisions of this Constitution and that they are approved by a two-thirds vote of the members of Council present at any meeting regularly called for the consideration of same. If, however, objection be made by any member of Council to a by-law or regulation so proposed, it must be submitted in writing for the action of the entire Council and will not be finally adopted unless a majority of the Council signifies its approval.

Article IX.

Amendments.

1. Proposed amendments to the Constitution must be reduced to writing and signed by not less than ten members. They shall be forwarded to the Secretary at least ten days before the annual general meeting, and shall be immediately forwarded to the Council for its consideration. If a majority of the Council approve the proposed amendment it shall be presented to the Society at the next ensuing general meeting for discussion; if approved by two-thirds of the members present, voting by ballot, if a ballot be demanded, it shall be adopted.

REGULATIONS

(See Article 2, paragraph (7), and Article 7, paragraph (1) of Constitution.)

ADOPTED BY THE COUNCIL OF SOCIETY, NOVEMBER 18, 1921.

Benefactors.—Before becoming eligible for enrollment as Benefactors, candidates must have evidenced special interest in the objects for which this Society was founded and have contributed at least five thousand dollars towards a scholarship, a special fund, or the general endowment fund of the Society. For those who are already Permanent Members, this contribution will be not less than four thousand dollars.

Permanent Members.—Those eligible for Permanent Members must have the qualifications prescribed by the Constitution for candidates for Members or Associates and have contributed at least one thousand dollars towards a scholarship, a special fund, or the general endowment fund of the Society. For those who are already Life Members, this contribution will be not less than the difference between one thousand dollars and the amount of the Life Membership fee previously paid.

The names of all Benefactors and all Permanent Members will be placed in special lists and will be published in perpetuity in the annual Transactions of the Society, the names of the deceased members being appropriately designated.

Benefactors and Permanent Members shall have the right, subject to approval of Council, to designate by will or otherwise their successors, to whom shall be sent the published Transactions of the Society. This privilege of designation of successors shall pass from original beneficiary to his successor in due course, subject in all cases to the approval of the Council.

SPECIAL MEETING OF THE SOCIETY HELD AT THE AUTOMOBILE CLUB OF AMERICA, 247 WEST 54TH STREET, NEW YORK CITY, MAY 19, 1922.

SPECIAL MEETING OF MAY 19, 1922

PRESIDENT WALTER M. MCFARLAND:—As you realize, gentlemen, from the program as it has been stated to you, we have quite a lot to do in one evening. We are to have the pleasure of an address from a distinguished member of Congress and, perhaps unexpectedly to you—it was to me—we are also to be favored with a few remarks from one of our veteran ship operators. After that we are to have the meeting, with the reading of the paper by Captain O'Donnell. Consequently we want to start in now with this post-prandial oratory.

At the present time everybody connected with maritime interests is, I think, looking with intense interest at the proceedings in Washington with regard to what is known commonly as the Merchant Marine Bill of 1922. It seems to most of us that the passage of this bill means the salvation of the American merchant marine and of the shipbuilding industry in this country.

Sometimes when people have been to see Congress at work and have met some of the legislators, they come away feeling rather discouraged because they think that the congressmen do not know very much about the subjects on which they are legislating. It is, however, fortunate that there are men in Congress who do know what they are talking about and what they have to consider in the way of the advancement of the interests of the country. We are very fortunate in having with us here this evening, as our guest of honor, one of those congressmen who does know what he is trying to do. Unlike the great majority of congressmen, he is not a lawyer; he is a business man, and as a business man he has been able to study this problem of the needs of the American merchant marine and to understand it. I have had the privilege this evening, while we have been sitting here, of chatting with him a little, and it has been a delight to me to find his thorough grasp of the situation.

He has kindly consented to make us an address tonight, and I know you will all be delighted to hear from the Hon. George W. Edmonds, of the House Committee on Merchant Marine and Fisheries. (Applause.)

HON. GEORGE W. EDMONDS:—Mr. President and gentlemen, you know if you keep your eyes about you you will always learn something. As we came over here tonight on the Pennsylvania train we passed through Elizabeth. I saw a great big sign, "Haynes, Funeral Director." I was wondering whether that was our Prohibition Commissioner down in Washington. (Laughter.) I presume it is. (Laughter.)

When your president and your secretary asked me whether I would come over here and talk to you tonight, I remembered the very delightful reception you gave me at your banquet a couple of years ago at the Waldorf, when I talked there and Judge McCrate made an eloquent speech. I have been trying to get him over to Philadelphia ever since to make a speech for me, and he won't come; he says he is too busy over here.

But I presume that you are all more interested in knowing a little something about the shipping business. To go back a little into history, I think the first ship was built in this country about 1728; it was built in Maine. We progressed from that time until 1850. After the Constitutional Convention, when we framed up a constitutional government in 1783, the first four or five bills that were passed by that Congress, or the first four or five out of the

first ten bills that were passed by Congress, were in connection with shipping. From that time on no country on earth had a greater opportunity of being the maritime power of the world than had this country. Unfortunately, and without criticism, because I presume those men did the best they could, either through over-confidence of our ability or because perhaps of foreign relations, we gradually let slip from us what we had.

In 1848, when we allowed the English nation to enter into our indirect trade, we built a cemetery for our ships. However, the eyes of the country had turned in another direction; the discovery of gold in California in the forties and the vast number of people, caravans, crossing the country, had turned the eyes of the people to the development of the west. Immediately the financial powers, and, I presume, the people, asked of Congress the opening up of the west.

The country was not rich, we had had a Civil War on our hands, and we did not feel that we had too much money; but Congress subsidized the railroads of this country to build up the west, and the most amazing thing to me, gentlemen, is that the farmers of the west, who are living today off the subsidy that was paid by Congress to put the railroads through to give them their farms and the opportunity to market their products, are the people who are kicking about subsidizing the merchant marine.

Going back over the list, I find that almost every community paid a railroad to come to it; that nearly every state and municipality paid a railroad to come to it; that the National Government, besides putting out money, granted to these railroads 210,000,000 acres of ground to build them up. And the very men who come today to Congress and say, "We cannot stand a subsidy for the ships," are the very men who are benefiting off the legislation and the subsidy passed by Congress at that time for railroads.

I am going to go back to the bill. When we started last fall to find out what legislation was necessary—and I would like to explain to you that we could not start before last fall for the simple reason that nobody knew where the Shipping Board stood until that time, notwithstanding the fact that Mr. McAdoo and Mr. Hurley and a number of other of those prominent gentlemen who were identified with shipping had made marvelous speeches around the country as to the way we were building up our tremendous merchant marine. I doubt very much whether they ever knew very much about it. It took us six or eight months to clean the thing up,—and I am not talking politics now; anybody who took charge would have had the same trouble. When we began to get some idea of where we stood, we tried to find out what could be done with the material in hand. Fortunately, we did not have to look for ships; we had them. Heretofore we had had to subsidize companies beforehand so that they would get ships; this time we had ships that we could start with.

So the first thing that appeared to us was this; in subsidizing before we had subsidized individual companies or individuals, and in doing so had led to such scandals that we had made the question of a subsidy for ships unpopular. The second thing was that, if we were going to pay a subsidy, we did not want to pay it forever; we wanted to give these ships as much indirect aid as we could possibly do under the law, or make a law for it, and in doing so, after we had established their lines, we hoped we would not have to continue giving a subsidy forever.

So the bill that is before us today was drawn up with this idea in view: first, that there should be no favorites in getting a subsidy; second, that we would give all the indirect aids that we could, so that eventually these indirect aids would carry the shipping without the assistance of a subsidy.

Mr. Lasker and the Shipping Board called in a number of experts to test out the subject. I well remember the first meeting we had, early in December. They had been working then for two or three months. Mr. Greene, Mr. Jones and myself were at the meeting. I presume we were some kind of a board of arbitrators; we were supposed to listen to what these committees reported, and after they were finished we found much that we did not agree to. After arguing the matter we sent them back to work again. We told them that they would have to work Christmas week, we made comments on what they had done, and questioned some of the things that they had proposed.

They came back in the first week of January with a very much better proposal, and from then on this bill has been worked out. I have no doubt most of you know about it. The bill has been drawn, as our Democratic friends who are opposing the bill say, very cannily; they don't like this return of part of the profits if a man earns above 10 per cent. That was an idea that I proposed myself three years ago when I wanted to start lines to South America. I am not quite sure whether anybody is pleased with it, but the fact must be recognized that the Government cannot pay a subsidy to a man who is making 30, 40 or 50 per cent.

The subsidy, it is said by the shipowners, is not large enough. No doubt we will take that question up when we get into executive session, but I am of the opinion that the subsidy is large enough, because if it is made too large you will not have the incentive to initiative that we want to give to the shipowners.

As to the indirect aid, we want to abolish the transport service as far as we can and have them use the private ships. A good deal of question has been raised about that. They say we ought to have naval auxiliaries, or we ought to have a military service, trained. As a matter of fact, what better trained military service could you have than a lot of good mercantile ships commanded by captains who know their business? They figured out that they were saving money for the Government. Taking their entire fleet as a proposition, from their own figures we are losing from six to eight million dollars a year over what it would cost us in ordinary service if we paid the commercial rates.

We want our Ambassadors and other government employees to use our ships. We want to have a relationship between the Interstate Commerce Commission and the Shipping Board that will take care of the shipping interests. Heretofore the Interstate Commerce Commission has been leaning toward the railroad interests, and we do not think it is fair. We want to give the shipper a reduction in his taxes if he ships on American ships, and I say to you gentlemen that that is simply another way of looking at the question of a differential or preferential tariff. If a shipper can get a deduction in his income tax on his shipments, it pays him to ship in American ships, and therefore we will have cargo for our ships. The only unfortunate part about that is, of course, that it does not bring the return from the imports that it does from the exports.

As to shipbuilding, we have arranged in the bill that the $125,000,000 that was proposed in the Jones Bill shall be available at once; and I agree with Mr. Lasker when he said yesterday at the Chamber of Commerce that our fleet is not well balanced as far as our ships are concerned. We need more of certain classes of ships. We have as many tankers, probably, as we can use today; we have very few refrigerator ships. We have not enough passenger ships. We ought to have, and I think we will have some day, the proper ships to balance out this fleet. We have got too many lake type ships; we want to get rid of them. We want to get rid of the wooden ships. We want to carry on and use the four, or five or six hundred good ships that we have got today in the cargo business, ships that can carry

on properly and economically. We want to see that 50 per cent of the immigration comes here in our ships. As long as we have provided for ships, the people who come to this country should be perfectly willing and should acquiesce in such a measure. If we allow them to come into the country, they ought to grant us the privilege of telling them how they can come into the country.

The Naval Reserve, I believe, will be taken out of the bill. That will be left to future discussion. It has raised a question with the labor unions as to how this Naval Reserve would be used in case of a strike. I think they are justified in raising the question.

Personally, if I could see the captain in command of the ship, I would not care so much about the La Follette Bill. I believe that the La Follette Bill has been more maligned and talked about than it deserves. The question of the cost of a crew on a ship is only a small percentage of the operating cost as compared with the cost of the overhead. The question of the additional cost caused by the La Follette Bill is not as great as the newspapers have made us believe. But the question of the command of the ship, after it gets outside of the 3-mile limit, is a very important one, and one that we should see is carried out in full.

Unfortunately, whether on account of the war, on account of conditions, or on account of sea lawyers, I believe they call them, the captain has not command of the ship. That is a very serious thing in operating ships. I think that some of the captains are unfortunately to blame. As a matter of fact, when trouble comes on the ships, I think the captain is mostly to blame.

I received a report from every consul in the world, through the State Department, showing the operation of the La Follette Bill. It is on my desk in Washington. In one case in Rotterdam we had to find the captain along with the crew and to hoist them all on board in nets, because they couldn't get on any other way. (Laughter.) That took in the chief engineer, all the engineers, and all of the officers. The consul took charge of the ship because there was nobody else to take charge of it.

In another case we found the officers acquiescing in the looting of cargo along with the crew. It is bad enough to have the crew looting the cargo, without the officers. One of them said with a great deal of pride that he had not a stitch on him that he did not get out of the ship; it did not cost him anything. He had pretty good neckties, better than I wear, and he had a better suit than I wear. He had beautiful silk stockings and a better pair of shoes than I wear. He said with a great deal of pride, not knowing that I was present when he was making the remark and that I was interested in the matter, that he had not paid for a stitch he had on him, and he was an officer on a ship.

That is our trouble today. We lack the knowledge of the conditions that exist and how to cure them. We must learn by experience, and we in Congress hope, if we pass this bill and give a subsidy, that experience will come with time, and that when it does come there will not be any necessity for a subsidy, because I do not believe that the cost of operation of an American ship, if the overhead is the same, is very much different between our ships and a foreign ship.

We have covered in the bill, we feel, all the possible grounds that we could find for giving assistance to shipping. Frankly, I will say to you that Mr. Furuseth has agreed with me to discuss the Seamen's Laws, and I think we will probably get some correction in the Seamen's Laws. He agrees with me that the captain ought to have charge of the ship, but he says the blame is on the captain, while I say it is on the sailor. So we are fighting that matter out, but he has agreed, after this bill has passed, that he will take up the question of the modification of the Navigation Laws; one thing he has agreed to is that the

sailor should carry a discharge book. That is one of the things that I tried to bring into the La Follette Bill, which Mr. Furuseth opposed in 1914. I think it was, when we passed the bill, but today he admits that it would be a good thing. But he does not like to have the man's character put in the book. We may come together at some point on that, too. He has read the consular reports that I had, and I think we will find that Mr. Furuseth, if we pass this bill, will probably be reasonable in trying to see that the captain has control of the ship after it leaves the port.

I do not know that there is much else in the bill. There is a question, a number of questions, in it that probably might not interest you; at the same time they are questions that we must decide. One is whether railroads should own steamships. As a matter of fact, there is nothing in the law today to prevent them from owning steamship lines. The real reason, I think, that the railroad companies have not bothered much with shipping is because they could make better contracts with the foreign lines. And the real reason that they could make better contracts with foreign lines, as near as I can see, was the fact that they could get attractive through bills of lading.

Now the question of bills of lading has been taken up in Washington, and after we get through with this bill we probably will have something to say about that. I noticed the other day that the Canadian Pacific Railroad, together with the Canadian Pacific Steamship Lines, had entered into a contract with the railroads of Italy by which a man can ship from any point in Canada to any point in Italy on a through bill of lading. Unfortunately we have not been able to do that. Whether it is on account of the opposition of the ship lines to railroads owning the lines, or whether it is necessary for the railroads to own the lines, is a question that I have not been able to decide. It is my opinion, however, from looking at it from the present viewpoint, that if we got a good bill of lading that would at least mean something, instead of this foolish, silly bill of lading that is promulgated today, which contains so many provisions which the poor unfortunate shipper does not know are null and void and could not be sustained if taken into court, possibly we might be able to settle the question of a through shipment.

I was very much amazed on Wednesday night of this week to find out that almost 50 per cent of a bill of lading could not be carried out in court if you took it there. Yet the poor shipper, when he has a loss which can be brought under some provision in that bill of lading, has it shoved under his nose and is told, "Here, you signed this; this is what you agreed to." Yet the very thing that they are telling, the parties themselves know is a violation of the Harter Act and cannot be carried out in court if taken there; and when I asked one of the lawyers why they put that in he said, "Oh, well, we put it in because, you know, a lot of these fellows don't know that." The Harter Act fortunately says that any provisions contrary to the act are null and void, so that the carriers, with their usual good judgment, and with the idea of building up an American merchant marine, have a habit of sticking in everything they find new in the bill of lading, so that they can at least try to bluff the shipper out of an honest return that he is entitled to, rather than pay him as they ought to do.

So, you see, there are hundreds of questions that come up with the merchant marine. There is insurance; there is banking. We find we are having difficulty with our foreign banking companies that we thought were progressing so nicely during the war. We do not welcome their concerns here as they do ours; therefore they legislate against us. I understand that they are passing laws in some of the South American countries against the banking institutions that we have established there, taking away from us privileges that English banking companies have.

We have got the question of insurance, the question of banking, the question of bills of lading, the question of the sailors' end of the laws, the question of this shipping business, the question of the subsidy—a thousand and one questions that arise out of this business, which is so peculiar in itself.

And yet with it all the committee hopes, and I think Congress hopes, that we shall see a return to our country of the prosperous condition of the merchant marine that we had in 1850, 1840, 1830, and that American ships shall be the best ships in the world, as they were in that day; that American sailors shall be the best in the world, as they were in that day; and that we will get our fair share of the carrying trade that we are entitled to. I do not believe that the Englishman, down at the bottom of his heart, objects to our having our fair share of the carrying trade. I do not believe that any nation objects to it. But I do know that they are doing exactly what I would do—they are endeavoring to stop us if they possibly can, because they would like to have all of our carrying trade themselves.

Yet is it not silly for the farmer to place himself in the hands of a foreign carrying corporation? Would it not be silly for Gimbel Brothers down here, or Wanamaker, or some other of your big department stores, to ask the American Express Company or some rival concern to carry their goods? It would be queer if Wanamaker should ask Gimbel to deliver his goods, because Wanamaker's goods would never be delivered as long as Gimbel's were to be delivered.

I think you will find, if you investigate, that the general policy of a foreign country is to utilize its own products first. I think you will find that Canadian wheat is used up before American wheat is used up; I think you will find that Argentine wheat is used up before American wheat is used up. In other words, if these countries can get all the wheat they want from Argentine and from Canada, your wheat stays in the storage houses. Unless you are prepared with your utensils, with your own wagons, to deliver it to the door and compete, you are not going to do the business, because whenever they wish to shove you on one side and carry the other fellow's goods they can do so.

The farmer is foolish in standing in his own light. If he could only realize that he must have his market and his market has to be cared for. These things come before us continuously, shown to us in different lights, and different people talk about them in different manners.

But above it all we want an American merchant marine. Why, it would make any man's heart proud to see the American flag on the sea like it was in 1850 and 1840, when we had the best ships, the best crews, the best men, the best merchants in the world; when for a short time we were *the* maritime nation, and we let it slip away from us without any care as to what we were losing. Now our opportunity is here; we have the ships, we can get more ships if we want them, and a great many men have been trained in shipping lines. There is no reason why, with a little assistance from the Government, we ought not to be able to put it over; and I do hope that every ship man and every merchant and every farmer and everybody in this country will just put his shoulder to the wheel and let us put it over, and let us see whether we cannot again regain the prestige that we had in the fifties. I thank you. (Applause.)

THE PRESIDENT:—Gentlemen, your applause shows that you appreciate very thoroughly what Congressman Edmonds has told us, and I am sure that you must all feel a renewed sense of hopefulness when we realize that a man with this grasp of the subject is one of the most

active and influential men on the committee that has this subject of the rehabilitation of the merchant marine in its charge. I for one feel that we ought to take great encouragement from what he has said and look forward probably within a few months, or certainly within a year, to the passage of the bill. We know that the President has already committed himself to standing ready to approve the bill when it is passed, so it is only a question of getting it through Congress.

I feel that we owe a debt of gratitude to Congressman Edmonds for having come over from Washington to talk to us, and I am sure that in your behalf I may tender him our hearty thanks.

HON. GEORGE W. EDMONDS:—I am glad to be here.

THE PRESIDENT:—It is always a pleasure in any organization when one of the old timers, a man who has made a big reputation, a man who has gone through the hard times and the good times, happens to drop in with the boys and is willing to say a word to them and tell them something about what he has been through and something about how he looks on existing conditions.

There is a man here tonight whose name is known to everybody that has any interest in American shipping. He has been a ship operator for a great many years, and he has had the reputation of being one of the shrewdest and ablest men in the business. He has kindly consented to say a few words to us, and I have great pleasure in introducing to you Captain Robert Dollar. (Applause.)

CAPTAIN ROBERT DOLLAR, *Member:*—Mr. Chairman, fellow members, I thank you very much for this high honor that you have conferred on me. I am not able to talk to you gentlemen, so to speak, in your own language. You are shipbuilders, you produce ships; but I can talk to you somewhat about a ship after she leaves the yard.

The chairman has asked me to say just a few words; I do not know just exactly what to say to you. There is a great deal of discouragement in it. I addressed a banquet in Singapore a few months ago, and I said to them there, "My great grandfather wrote a letter from Singapore in 1796, in which he said that 'I am pleased to report that this great big ship that I have has got a full cargo of 600 tons, and that she will be loaded in three weeks. We are getting good despatch.'" (Laughter.) I said to them, "I came in here a couple of days ago, into your harbor, on a ship that required 16,000 tons, and I raised merry hell with one of your fellows because you only put a thousand tons in her the other day." (Laughter.) It shows the great change that has taken place. If you think back, then you will be encouraged.

Of course, I talk more particularly of the Pacific Ocean, because I am doing a little more there than I am on the Atlantic. It is only fifty years ago since the first steamship went across the Pacific, and now the commerce is tremendous.

What I am going to say to you, you could not very well credit, so I will prefix it by stating this: What would the Phoenicians have said, when the center of the commerce of the world was in the Mediterranean, if someone had said that the center of the world's commerce is going to be in the Atlantic some time hence, when America even was unknown to them? But what I am going to say to you is this. We know that Asia is on the other side of the Pacific, and there are young men in this room here who are going to live to see the commerce of the world transferred from the Atlantic to the Pacific. That is a prediction, and I am not afraid to say it when I come to look at the progress that has been made.

I will say only just a few words about the subsidy, because the congressman has explained that quite fully. I am in hearty cooperation with him about the subsidy. We need a subsidy and we must have some subsidy. The subsidy they propose is only going to be a help. But what I have got to say is this, if I am able through all the hard times we have had to operate British ships and ask no subsidy, never got any, and have made a certain amount of success out of it, if our laws and our regulations were exactly the same why couldn't I operate American ships just the same? Every law that ever was put on the statute books recently is on it today. Those laws put our merchant marine off the ocean, drove it right off the ocean, and those laws are all on the statute books; but they are not enforced. But it is like holding a club over a fellow's head; some day it will come down and break our heads for us.

On the Pacific we had the Pacific Mail. That was the oldest company there; they were driven off the ocean. James J. Hill, the grand old man, put ships on the ocean and lost a fortune by operating them and had to go off. The Boston Towboat people from Boston put a fine fleet of ships on the Pacific, and they are gone. Two months ago there was not a privately American owned cargo ship on that great Pacific Ocean. I repeat that again, there was not one privately American owned cargo ship on the Pacific Ocean. Is that not a commentary? Not a single one. There are four now; I bought four from the Government and put them on there, and God knows whether I will succeed with them or not. (Laughter and applause.) I told Mr. Lasker when I bought them that I was going to put them on the ocean, and I was going to try, and I said, "I am going to do my damnedest, and whether I will succeed or not I don't know." (Laughter.)

There has been a great deal said about the cost of ships. That is something we are interested in. I read in the paper, I do not know whether the party was correctly reported or not, but he said that he did not know of ships having been sold in Great Britain previous to the war at less than $45 a ton. Now I have contracted to get ships built in Great Britain, several of them, and I never paid $30.

As to the wages, a great deal has been said about them. "Oh, there is only just a little bit of difference between American wages and the British wages. It doesn't make much difference. And then, our conditions are just about the same, and all it wants is the superior energy and get-up of the American shipowner, and he will overcome it all." I want to tell you it is a mountain to overcome.

I have taken some figures off my own books; not what some fellow told me. I took them just before I left home. An American ship that I am operating with an American crew costs $3,718.50 a month. A British ship that I am operating with a Chinese crew costs me $1,567.20 a month. A Japanese ship that I am operating—I have got six of them—cost me $1,403.12, very nearly the same as the British.

Take the American ship for twelve months and the British for twelve months; it is $25,715 more that I would have to pay with my American ship than with my British ship. Some good people tell us, "Oh, that is not much"; but I want to tell you, if you multiply that by about twenty, if you have got about twenty ships, they would soon begin to think it is plenty. (Laughter.)

The subsidy which is proposed on a 10,000-ton ship operating on the Pacific, just as our ships are operating, would give us $12,375 a year. That, you see, taken off from the wages, would be only about half what we have to pay for the crews, just for the wages and the board. That is the reason I say it will help; it will help some, just a little. (Laughter.)

What we want is shipowners, and that is what we lack. You get a shipowner who has a ship, I do not care where, and he cannot get a cargo; why, that man will do everything short of stealing, and some of them do steal, to get a cargo for the ship to get her back home.

It is said that it does not make much difference what kind of a ship you employ. It does make a difference. Do you think that I am running my ships in an effort to develop the trade of Liverpool or London or Madrid or any other place? Not at all. I am trying to develop the commerce of the United States and lie awake nights most of the time doing it. (Applause.)

I have been accused, and I plead guilty, of operating British ships. Well, why the devil do I do it? Because I could not operate American ships; I did not have money enough. And it would take a man with a pretty long purse to operate American ships in the foreign trade. It cannot be done, gentlemen, under our laws; and if we would only enforce our laws to the letter—and I would ask our congressman when he gets back, for God's sake enforce the laws to the letter, and no ship can sail from an American port; you will tie up the whole commerce of the country. There is a great deal of delay in the inspection of our ships; that a good many of you understand. With the British and the Japanese there is no delay; the inspectors have orders not to delay the ships. If they cannot finish an inspection they will do it at the next opportunity. But with our laws they have to be inspected and finished at once.

There are a great many things that militate against it. A man brought a proposal to sell a ship into my office this afternoon; he wanted to sell the ship. I looked at it. I said, "I have got a ship, just a duplicate of that, but," I said, "your ship is 5,000 tons net. My ship is only 4,080 tons net." I said, "With your ship, you have got to pay on a thousand tons more than I do every time you put your ship into the dry dock; your pilotage and all charges, dues that are assessed against a ship, on your ship you have got to pay one-fifth more than I have."

For the last twenty or twenty-five years I have been trying to talk to them in Washington about that, but it is of no use; they will not make any change, but they measure our ships bigger. Colonel Goethals here awhile ago was telling of two sister ships, one a British ship and another an American ship, going through the Panama Canal, and it cost $500 more to put the American ship through the Canal every time than the British ship. I would say to our congressman, when you get back please look into that and try and hammer some horse sense into our fellows down there. (Laughter and applause.)

I was only to take ten minutes, and I am pretty sure I have talked more than ten minutes, so I thank you for your attention. (Applause.)

THE PRESIDENT:—I know it has been both a pleasure and a privilege to you to listen to this veteran of the American shipowning profession, and it is easy to see how much you have all enjoyed it. I am sure you will all wish me to tender your hearty thanks to Captain Dollar for his most interesting talk.

CAPTAIN DOLLAR:—Thank you.

THE PRESIDENT:—Now, gentlemen, we will adjourn from this room, and Mr. Cox will lead the way to the meeting room, where we are to hear the reading of the paper by Captain O'Donnell, and such discussion as may occur in consequence.

President Walter M. McFarland in the chair.

The chairman called the meeting to order at 8.50 p.m.

THE PRESIDENT:—Fellow members of the Society, this is the second time in the history of the Society when a spring meeting has been held. It was the belief of many of the most active members of the Society that one meeting a year gave ample opportunity for the presentation of papers and discussion of matters of importance. Other members, however, urged the desirability of a spring meeting, and the Council finally decided to hold this one, partly as a test of the interest which the membership at large would take in a spring meeting.

Owing to the forethought of our most efficient secretary, advantage was taken of the initial trip of the Majestic to arrange the date of the meeting so that a visit to this great ship could be included as one of the attractions. Most of you probably inspected this vessel, the largest in the world, this afternoon, and undoubtedly feel that you are repaid for coming to the meeting.

At the annual meetings of the Society it is customary for the president to give a summary of the general situation in maritime affairs during the preceding years, with special reference to elements of progress. During some recent years, when there was the tremendous boom in shipbuilding, both for mercantile and naval purposes, this work of the president was a very agreeable one. After a long period of intense discouragement in mercantile matters, it was, of course, a delight to us all to realize that the output of our yards was the greatest in the world, and that we were building up a merchant marine second only to that of Great Britain, and apparently in a position to rival hers.

At the present time, however, it requires great optimism and strong faith to be cheerful. The naval holiday is a terrible blow to our great shipyards, for which the building of naval vessels has for many years past been the real backbone of the business, and the school in which naval architects and marine engineers have gained experience with the highest development of the profession.

The limited time for this address precludes any detailed discussion of this condition of affairs, and, moreover, it has been discussed in public addresses and in testimony before government committees by several of the leaders of our profession, so that we are all familiar with the situation which confronts us. I believe I voice your sentiments in saying that, in view of the naval holiday, it is most important that there should be encouragement for the building of large, fast merchant steamers, which will keep our designers and builders in practice, so that when the time comes for designing war vessels the skill and experience necessary will still be available.

This does not agree with the views of our pacifist friends, who believe that there will never be any more wars, and who talk of navies that will be reduced to the condition of a maritime police. In the last analysis, wars depend upon human nature, and the teachings of history seem unquestionable, that human nature has changed very little since the earliest records. We used to flatter ourselves that the race had become more civilized, and that warfare in modern times could be conducted without the barbarities of the early days. Alas, the great war showed that a country which was supposed to be in the very forefront of civilization would abandon all the amenities of civilized life and wage warfare in a way fit only for savages.

During the war we liked to believe that all of us who were fighting for civilization and for liberty were actuated only by the highest possible motives, but the reports of what has

occurred at the great conference which came to an end today certainly showed that altruism had very little consideration, and that human nature has reasserted itself very strongly.

You have heard the address of our good friend Congressman Edmonds, and the words of encouragement which he has brought us as to the probable passage of the Mercantile Marine Act of 1922, which most of us look upon as the salvation of the American merchant marine. It has always seemed astonishing that Americans, who pride themselves on being good business men and who believe in the protection of American industries, should have treated the merchant marine in the foreign trade as a Cinderella. Probably the difference between our attitude and that of Great Britain is due very largely to the difference between a continent of 3,000,000 square miles and an island of about 50,000. One cannot go very far in England in any direction without coming to the sea, whereas in our great expanse there are millions of people who have never seen the ocean. Conditions during the late war, however, brought home to our agriculturists and other inland dwellers the helplessness of a country which depends upon foreign bottoms for transporting its cargoes, and it is extremely gratifying to know that at the present time the agriculturists have come out strongly in favor of protection to the merchant marine so as to insure an American fleet for carrying American products.

The basic reason which calls for government help to insure the success of our merchant marine is the higher initial cost of our vessels and the higher cost of operation, both due to the higher scale of wages which obtains in this country. We have all been proud to think that the condition of the laboring man in America was better than in other countries, but it seems only fair to ask some appreciation of this fact by him, and some adequate return for this greater wage. It is a fact that the output per man in our industries is greater than the corresponding output in the countries with the lower wage, although this is due in part to a greater use of labor-saving appliances. There is little doubt that, if the wage earners would exert themselves to greater efficiency, the margin between costs abroad and costs here could be very much reduced. If the present difference in wages is to be maintained, it can only be as a result of greater efficiency by our people. This means that the labor leaders, instead of encouraging strikes and constant demands for higher wages irrespective of conditions of business, should turn their attention to encouraging their followers to give the best that is in them, so that not only will they receive the highest wages but will also deliver the highest output.

Only recently an English engineer who was rewarded with a peerage for his wonderful work in the Great War in the supply of airplanes, Lord Weir, called attention in a lecture at Greenock on March 24 to this very point in connection with conditions in Great Britain. Wages in England as compared with those on the Continent have much the same relation as our wages compared to those of England. He called attention to the fact that if Great Britain is to continue prosperous and there is to be employment for the workers, one of two things is absolutely necessary—either more output for the existing wages or lower wages for the existing output. It is a very difficult problem which, in our case, as in that of nearly all other countries, has been immensely complicated by the conditions obtaining during the war, when wages were enormous and output per man was very low. However, "it is a condition and not a theory" that we have to face, and we, as the leaders in our line of work, must do our best to hasten a satisfactory solution.

We had arranged with a distinguished member of the Society, Captain O'Donnell, to give us a paper on the "Operating Problems of the American Shipowner." Captain O'Don-

nell has the fortunate position of having been a government official at one time as the supervising inspector at Boston, and more recently managing director or operating manager of a line of steamers, so that he is in a good position to discuss this subject with both aspects of the case before him. Unfortunately, Captain O'Donnell could not get here tonight, but another gentleman, one of the leading shipowners and ship operators of our vessels in the Atlantic, has kindly consented to read the paper. I have the pleasure of calling on and introducing to you Mr. Alfred Gilbert Smith, the president of the New York and Cuba Mail Steamship Company, who will read Captain O'Donnell's paper. (Applause.)

Mr. Alfred Gilbert Smith, *Associate Member:*—I am very sorry indeed that Captain O'Donnell is not here. Personally I regret it very much. I am sure that those of you who know him are very sorry, too. I fear that all of you will be sorry after I attempt to read this paper.

Captain O'Donnell is eminently well qualified to speak on the subject with which his paper deals, in that, as Mr. McFarland has said, he has held a very important and responsible position in the service of the Government and is, in my judgment, one of our best authorities on the navigation laws of the United States, particularly as they refer to the matters of inspection. He also qualifies eminently well in dealing with the subject of compensation to officers and crews of ships, in that he has been, as many of you know, chairman of the Committee on Crew's Wages and Working Conditions of the American Steamship Owners' Association. He has had exceptional opportunities to study the question from every angle, to make comparisons between the wages paid in American ships and those paid in ships of foreign flags; and I say this because, as you will note as we go along, he makes particular reference to this and lays especial emphasis on it.

One word more (perhaps it is hardly necessary for me to say it), and that is that Captain O'Donnell, whom it is a great pleasure to know, believes in what he says and says what he believes.

Mr. Smith then read the paper on "Operating Problems of the American Shipowner," by Eugene E. O'Donnell, Member of the Society.

OPERATING PROBLEMS OF THE AMERICAN SHIPOWNER.

By Eugene E. O'Donnell, Esq., Member.

[Read at a special meeting of the Society of Naval Architects and Marine Engineers, held in New York, May 19, 1922.

I speak as an operator of cargo steamers in both the coastwise and the overseas trade. Many of the problems are substantially the same in domestic as they are in foreign commerce. But as it is the internationally competitive trade which is now attracting the chief attention, I will devote most of what I have to say to considerations applicable to that field, though not forgetful of the other.

Never before in maritime history have operators had to wrestle with the problems of so great a suddenly created merchant marine. In other nations the growth of shipping has been gradual. Here in America our gross register tonnage went up from 8,871,000 in 1917 to 18,282,000 in 1921. All of the amount of this increase was in ships designed for international commerce.

Not only has our tonnage thus rapidly multiplied, but American owners and operators have been compelled to face, in most cases with little experience, the exigencies of strange new trade with the ports of distant foreign countries. As I survey the situation I cannot but be surprised not that their mistakes have been so many but that they have been relatively so few. Operating organizations that five years ago had no particular knowledge of foreign trade now have excellent organizations and are working with smartness and efficiency. Not that there is not much yet to be learned by many of us, but I feel that a majority of American operators have thrown themselves into their new work with energy and determination, and that very remarkable results have been achieved in a relatively brief time.

Except for the vessels acquired before the war, which in many cases were carefully designed for the work in hand, it cannot be said that the merchant marine as a whole is especially adapted to its particular requirements. The new government-owned fleet was built not to constitute an ideally symmetrical merchant shipping but for the one imperative purpose of winning the war. Because of the supreme need of haste, the new fleet consists to altogether too great a degree of steamers of comparatively low speed and of the "tramp" order. We are lacking, of course, in swift passenger steamers, but we are lacking also in cargo steamers of the so-called liner type, which after all, if not the backbone of a merchant marine, is a class of ship of very great importance. This undeniably handicaps our owners and operators who contemplate the development of a cargo liner service, for vessels which have no reserve speed will necessarily find it difficult to maintain a regularity of service, especially in the trade like that of the winter months on the North Atlantic.

However, a considerable proportion of one-half of the steel tonnage of the Shipping Board which is characterized as good tonnage contains many ships fit for what may be described as the berth service to distant foreign ports, like the 7,800-deadweight-ton Hog Island ships, the 8,800-ton freighters and the larger shelter-deck and other steamers whose capacity in a few cases runs up to a maximum of 12,000 tons. Here is a fleet not to be despised in any survey of the world's shipping, and until we secure better steamers, these, outside of the "tramp" or bulk cargo service, must be regarded, together with the pre-war ships of the older companies, as the main, active, operating backbone of our merchant marine.

First of the problems of American ship operators in this connection is the hard, undeniable fact that they have to pay more money for the wages and subsistence of their crews than do their European or Japanese competitors. Let us assume that the Shipping Board

will carry out its promised policy of making the good steamers of the government-owned fleet available to purchasers at world market prices. There is still the handicap of higher cost crews. American shipboard wages have historically been from 30 to 40 per cent above British shipboard wages, and it is estimated at the present time that British wages are about 15 per cent above Scandinavian. This is a handicap which in my judgment, and I believe in the judgment of virtually all practical owners and operators, can be overcome only by national assistance.

A great deal is being carelessly said about the higher "efficiency" and "economy" of American officers and men. It is not to be denied that many years ago, in the heyday of our wooden-built merchant marine, there was a higher efficiency in American ocean ships than elsewhere, generally speaking. Indeed, this superiority was so manifest that it was freely acknowledged by our competitors themselves. But it must not be forgotten that this was an efficiency that had gradually been attained through many years of effort and experience. Such efficiency cannot be secured overnight or in a few months or a few years. It is a long, hard path our predecessors had to travel from the humble beginnings of our national merchant marine in 1789 up to the incomparable smartness of the celebrated packets and clippers of the thirties, forties and fifties of the nineteenth century.

It would be idle to pretend that any such relative efficiency has been attained in the brief period of the years between 1915 and 1922. Though we have in our ships many of the best officers in the world, our officers as a whole and on the average fall short of the experience of their European competitors. This is even more signally true of our crews. This is a handicap, however, which time itself will cure; in fact, any disparity on this point between Europeans and ourselves is even now rapidly lessening. I am one of those who believe that, given a fair chance, American officers and crews will gradually reestablish the supremacy which in the last century was theirs as the most capable men of their calling in the world.

The wage difference between American and British ships is somewhat less now than it has been of recent years, and must be regarded as temporary due to the abnormal condition of world shipping, but it is still a wide difference, as will be demonstrated by the comparison of the costs of wages and subsistence of an American and a British cargo steamer of 3,500 gross tons, and the wages and subsistence of an American and a British cargo steamer of 6,000 gross tons, shown in the tables on pages 17 and 18.

In this comparison a similar number of crew in each vessel has been used, but it is a generally accepted fact that American vessels carry a greater number in the crew than do foreign vessels. This difference is more especially to be found in the "tramp," coastal or short-voyage American steamers as compared with the foreign vessels; while in the case of the passenger liners or cargo liners the British manning scale more nearly approximates our own. On the other hand, the manning scale of Continental European ships will generally be found to be less than the British.

During and after the war an unusually large number of men were carried in our ships, because of the Shipping Board's manning policy in its endeavor to train the inexperienced recruits who came into the service of the merchant marine during the war. In recent years, however, with the inevitable reduction to a normal basis, leaders of seagoing unions have endeavored to make it appear that our vessels carry a less number in crew than foreign vessels. Recourse to the records of the Customs Department will, I am sure, clearly demonstrate that in the case of like ships in the same trade the manning schedule on American vessels will be found to be no less, but more often will be found to be higher, except in the case of vessels under foreign flags manned with the cheaper Asiatic labor, on which, how-

ever, the total wage scale will be considerably less than if the same vessel were manned with a European crew.

The manning requirements contained in the United States statutes as compared to the requirements contained in the British Merchant Shipping Act are illustrated.

Section 4463, United States Revised Statutes, provides that no vessel of the United States subject to United States laws shall be navigated unless she shall have in her service and on board such complement of licensed officers and crew, including certificated lifeboat men, as in the judgment of the local inspectors may be necessary for her safe navigation. An entry shall be made in the certificate of inspection covering the number of officers and men required.

A minimum manning scale for the officers is further contained in this section of the law which requires that every ocean or coastwise seagoing merchant vessel of the United States propelled by machinery and every ocean-going passenger vessel shall have a minimum number of licensed officers for the vessel's safe navigation according to the following scale:

"All such vessels shall have a licensed master.

"All vessels of 1,000 gross tons or over navigating on routes of more than 400 miles shall have three licensed mates.

"If the vessel is between 200 and less than 1,000 gross tons, two licensed mates are required.

"If the vessel is between 100 gross tons and less than 200 gross tons, one licensed mate; but if the time required to make the voyage from port to port exceeds 24 hours, two licensed mates shall be required."

WAGE COMPARISON—AMERICAN AND BRITISH OIL-BURNING STEAMERS, 3,500 GROSS TONS

APRIL 12, 1922.

	A. S. O. A. scale	British scale
Master	$265.00	£42 10 0
First officer	155.00	20 10 0
Second officer	130.00	16 0 0
Third officer	115.00	13 0 0
Able seamen (6)	285.00	51 0 0
Chief engineer	240.00	26 10 0
First assistant	155.00	19 10 0
Second assistant	130.00	16 0 0
Third assistant	115.00	13 0 0
Oilers (3)	165.00	33 0 0
Firemen (3)	150.00	31 0 0
Steward and cook	105.00	14 0 0
Second cook and baker	70.00	10 0 0
Messboys (3)	90.00	25 10 0
Radio	90.00	13 10 0
Wiper	55.00	.....
	$2,315.00	£345 0 0
		($1,507.65)

A. S. O. A. scale	$2,315.00
British scale, present exchange, $4.37 = £1	1,507.65
	$807.35
Subsistence difference	180.00
Total monthly difference	$987.35
Annual difference for 11 months at present rate of exchange	$10,860.85

Comparison of American and British Pay-Rolls—New Scale, 1922.

APRIL 12, 1922.

Comparison of wages of a steamer of 6,000 gross tons, 3 boilers, coal burning, suitable for general ocean tramping, under the British scale, United States Shipping Board scale, and the American Steamship Owners' Association scale.

	United States		United
	S. B.	A. S. O. A.	Kingdom
Master	$270.00	$275.00	45/-
Mate	165.00	165.00	20/10
Second mate	145.00	140.00	16/-
Third mate	130.00	125.00	13/-
Carpenter	65.00	70.00	12/10
Boatswain	.....	.....	11/10
Able seamen (6)	330.00	285.00	60/-
Ordinary seamen (2)	80.00	70.00	11/-
Chief engineer	240.00	250.00	24/10
Second engineer	165.00	165.00	20/10
Third engineer	145.00	140.00	16/-
Fourth engineer	130.00	125.00	13/-
Deck engineer	70.00	70.00	11/10
Oilers (3)	195.00	165.00	33/-
Firemen (9)	517.50	450.00	94/10
Coal-passers (3)	150.00	120.00	30/-
Steward	105.00	105.00	14/10
Cook	90.00	90.00	13/10
Second cook	70.00	70.00	9/10
Messboys (3)	105.00	90.00	8/10
Radio	90.00	90.00	13/10
	$3,257.50	$3,060.00	492/-
Pound sterling converted at $4.37			$2,150.04

	British scale of May 1, 1922	
	On S. B. scale	On owner's scale
United States	$3,257.50	$3,060.00
United Kingdom	2,150.04	2,150.04
Difference	$1,107.46	$909.96
Subsistence difference	240.00	240.00
Total monthly differential	$1,347.46	$1,149.96
Annual differential at 11 months	$14,822.06	$12,649.56

There is a specific requirement in this section that the officers shall be divided into three watches, and under this system the local inspectors require the same number of engineers as licensed deck officers.

The British Merchant Shipping Act is silent as to the number of unlicensed personnel required on board of a British ship, except in the case of emigrant ships which may be considered as passenger liners in the transatlantic trade or the liners to India, Australia or South Africa. The crewing of these vessels will be dealt with later in this paper. As to the licensed officers, I wish to direct your attention to the fact that the requirements are not positive or mandatory in the full sense and state as follows:

"1. Every British foreign-going ship and every British home trade passenger ship, when going to sea from any place in the United Kingdom, and every foreign steamship carrying

passengers between places in the United Kingdom, shall be provided with officers duly certificated under this Act according to the following scale—

"(*a*) In any case with a duly certificated master.

"(*b*) If the ship is of 100 tons burden or upwards, with at least one officer besides the master holding a certificate not lower than that of only mate in the case of a foreign-going ship, or of mate in the case of a home-trade passenger ship.

"(*c*) If the ship is a foreign-going ship, and carries more than one mate, with at least the first and second mate duly certificated.

"(*d*) If the ship is a foreign-going steamship of 100 nominal horse-power or upwards, with at least two engineers, one of whom shall be a first-class and the other a first-class or second-class engineer duly certificated.

"(*e*) If the ship is a foreign-going steamship of less than 100 nominal horse-power or a seagoing home-trade passenger steamship, with at least one engineer who is a first-class or second-class engineer duly certificated."

While it is acknowledged that most British ocean ships in the foreign trade carry as many licensed deck officers as American ships and frequently as many engineers, the character of the British legislation is such that they may reduce the number at any time and are not subject to the penalties for failure to carry the full quota, as happens in the case of American ships by virtue of the penalty clause contained in Section 4463.

With further reference to the unlicensed personnel on American ships, in addition to the authority reposed in the local inspectors which is contained in Section 4463, Section 2 of the Seamen's Act provides that the sailors while at sea shall be divided into at least two watches and the firemen, oilers and watertenders into at least three watches. The seamen may not be shipped for duty alternately in the fireroom and on deck, and the firemen may not be shipped to perform duty in the fireroom and on deck; while in the American ship on Sundays and holidays the crew shall not be permitted to perform unnecessary duties nor shall they be required to do duty on any week day of more than nine hours while the vessel is in a safe harbor. In this regard, let me again point out that the British law is silent.

Section 13 of the Seamen's Act requires that 65 per cent of the deck crew shall be able-bodied seamen and to obtain a full-fledged A. B. seaman's certificate a man must have at least three years' experience on the deck of a vessel at sea.

Section 14 of the Seamen's Act relates to the life-saving equipment and the manning of boats and rafts with a definite number of licensed officers, able seamen and certificated lifeboat men. All boats and rafts carrying more than fifteen persons are required to be in charge of a licensed officer or able seaman. The British Merchant Shipping Act is silent on the question of watches at sea and as to the requirement of the number of able seamen. Only in the case of emigrant or passenger ships does it carry a schedule as to crew requirements.

Again I desire to direct your attention to the moderate terms of the language employed.

"1. Every emigrant ship shall be manned with an efficient crew for her intended voyage, to the satisfaction of the emigration officer from whom a certificate for clearance for such ship is demanded; after the crew have been passed by the emigration officer, the strength of the crew shall not be diminished nor any of the men changed without the consent in writing either of that emigration officer or of the superintendent at the port of clearance.

"2. Where the consent of a superintendent has been obtained, it shall, within twenty-four hours thereafter, be lodged with the said emigration officer."

The Board of Trade regulations, however, contain certain provisions with regard to the manning of lifeboats and rafts. These regulations are not as stringent as the requirements of Section 14 of the Seamen's Act. In the case of a British ship a certificated lifeboat man may take charge of a boat or raft, and this permits stewards and other petty officers to take charge and thereby lessens the requirements as to the number of able seamen.

If American ships were everywhere in the majority in overseas trades, the wage difference might not be so heavy a handicap as it is at present. It is the foreign ships that are far more numerous, and their managers and operators are intrenched in position as ours are not. In order to develop our own merchant marine, we must take a part of their present trade away from our enterprising foreign competitors. I need not point out that it is difficult to do this with ships confined to a relatively few types, maintained at substantially higher costs for wages and subsistence.

There is only one way in which the result which we all seek can be accomplished, and that is by national assistance such as has been recommended to Congress by the American Steamship Owners' Association and the United States Ship Operators' Association in the representations which they have recently made to the Congress of the United States.

As a result of the great influx of officers into our merchant marine to man the war-built steamers, naturally a great many inexperienced officers found employment, which, coupled with the unrest then existing among so-called unionized labor, reduced the standards from pre-war efficiency. Happily this condition is passing, and through the process of elimination we now have on the whole an excellent corps of deck and engineer officers that is steadily developing to a point of high efficiency.

As to the engineer officers, it is a matter of regret that our inspection requirements do not make it obligatory that licensed engineers have an adequate shop training. It is more and more manifest that this is needed to reduce repair bills and maintain engine and boiler efficiency.

As to the firemen in coal-burning steamers, we have a present good supply, but relatively few of them are American citizens. The present shipping subsidy bill will certainly contain a stiff requirement of citizenship for the unlicensed members of the crew, at least in the deck and engine departments, and it is a question how such a requirement can be met in coal-burning firerooms. On oil-burning steamers a large force of citizen firemen, most of them young men, is developing.

One of our greatest present deficiencies is in masters of the requisite business training and experience for the overseas trade. Many excellent captains, good navigators, seamen and executives, have passed most of their careers in the coastwise or near-by trade and are having their first experiences with the purely business problems that present themselves in the distant ports of foreign commerce. It is desirable also that the chief mates of our foreign-going steamers, some of whom will soon succeed to command, should acquire as soon as possible a knowledge of business as it is conducted overseas.

I am of the opinion that a shipping subsidy law should not require an American percentage of more than forty, to begin with, in the deck and engine departments. It might follow in this respect the graduated increase in the proportion of able seamen as provided for in the La Follette seamen's law. Such a plan as this ought to be acceptable to seafarers. Even assuming that the present American percentage, including officers and unlicensed men on our ships, is now about 55 per cent, as the latest returns of the shipping commissioners in-

dicate, so high a percentage would not be found at all American ports, and as under present inducements some of our seamen are certain to desert, it would be difficult to maintain the required percentage in the ports of foreign countries. To develop what is apparently expected by Congress and the country in the form of an unlicensed seagoing personnel, the greater part American, will require close study and patient effort on the part of owners and operators of steamers in the merchant marine, and could best be obtained through a system of naval reserve training.

In the La Follette seamen's law are presented not a few difficult problems. This act was passed with the assumption that it would provide freedom—so-called—for seamen. The practical result, however, has been the lessening of discipline on American ships as reported by ships' officers and United States consular agents.

Our steamboat inspection laws and rules and other navigation laws and regulations were made the object of a very careful study more than two years ago by a committee of maritime men established by authority of the Shipping Board—a committee of which Mr. P. A. S. Franklin was the chairman. Mr. Alfred Gilbert Smith was chairman of the Sub-Committee on Construction and Inspection, and Mr. J. Parker Kirlin was chairman of the Sub-Committee on Personnel and legal adviser to the committee.

As is known to most of us, that committee completed its deliberations and presented its report to the Shipping Board two years ago, and the Legal Division of the Shipping Board is now engaged in recodifying and consolidating the navigation laws in accordance with the committee's report. I can do no better by way of indicating what ought to be done to cure the unjust or obsolete features of our maritime laws and rules than by summarizing the recommendations of this committee as this report was recently released to the press by the United States Shipping Board.

SUMMARY OF REPORT OF NAVIGATION LAWS COMMITTEE.

It was found that our navigation laws are scattered through a large number of volumes of statutes and regulations passed at different times, and in many cases amendments have been enacted with clauses repealing acts and parts of acts inconsistent therewith, making a comparative study of the various statutes and regulations necessary in order to determine just what the law or regulation is on any particular subject. It was found also that authority to make regulations which were to have the force of law and the responsibility for enforcing the laws were scattered among a number of boards and bureaus in different departments of the Government. The committee considered that next in importance to the recodification of the law was the consolidation of responsibility for enforcement in a single department.

When a number of statutes must be considered in order to obtain the law on a particular point, the average layman is bound to become confused, and this condition tends to create criticism which leads to a popular misconception of the facts.

In comparison, the British navigation laws are contained in a single shipping act entitled "The Merchant Shipping Act," which is a maritime code that is very clear and simple of interpretation. The administration of this Act is reposed in a single department of the government, namely, the Board of Trade. The enforcement of the laws affecting shipping is carried out through a single bureau, and this bureau, known as the Marine Department, is the only one with which British shipowners need concern themselves. Obviously, therefore, the enforcement of the navigation laws under such a system is stripped of the confusion and

frequently annoying features with which American shipowners, officers and seamen are confronted and has much to commend it when compared with our present system.

Steamboat Inspection Laws.

The committee found that much of the criticism directed at the Steamboat Inspection Service was due to the mandatory character of the laws under which this service operates and the fact that no discretion is left to the officers responsible for the enforcement of the law. The marine code of other maritime nations is much more elastic in allowing administrative latitude to officers responsible for the supervision and enforcement of maritime regulations. With a merchant marine composed of so many diversified types of vessels engaged in various kinds of navigation, the application of legislation which is general in character and does not consider in a practical manner each type or trade condition is rendered extremely difficult and, therefore, places on American shipowners burdens with which our competitors are not confronted.

Hydrostatic Test of Boilers.

An example is that of the hydrostatic test of marine boilers. The law requires that marine boilers be annually submitted to a hydrostatic test, using cold water, of one and one-half times the working steam pressure allowed. Practical engineers claim that it is unwise annually to subject marine boilers to a stress the result of which makes doubtful the value of the application of this hydrostatic pressure at such frequent intervals. As a comparison, the classification societies, the British Board of Trade and maritime governments generally require that the hydrostatic pressure be applied only at the original inspection of the boilers and thereafter at the surveyor's discretion, and as a rule it is not applied oftener than at the survey period which occurs about every four years.

A further requirement of the inspection laws is the annual inspection of the hulls of cargo vessels. At these inspections it is required that all cargo be discharged and the boilers emptied in order that the inspection may be made. This means a loss of from twenty-four hours to two or three days, depending upon the size of the vessel. Although the inspector might be satisfied that it would be unnecessary to subject the boilers to test or examine the hull of a vessel, the mandatory character of our legislation does not leave any discretion, and he is obliged to carry out annually all tests and inspection.

Foreign cargo vessels are not required to submit to these annual inspections and are subject to inspection only at the classification period, which is once in every four years. It is suggested that passenger vessels might very well be subjected to these annual inspections, with the exception of the hydrostatic boiler test, and that the life-saving equipment of all vessels should be annually inspected. The inspection of the hulls of cargo vessels might properly be made at the survey periods, once in three or four years.

It is particularly desirable also that American vessels trading between ports in foreign countries should not be obliged to return to an American port for the periodical inspections required by law and regulations made pursuant thereto. These inspections might well be carried out by representatives of the American Bureau of Shipping located in various foreign ports. This examination should extend the life of the certificate of inspection until the vessel's first arrival in an American port, as other maritime nations have similar regulations to provide for vessels away from their home port.

Seamen's Act.

It is the general belief that the repeal of the Seamen's Act will place American shipping on an equality with foreign vessels. This is not the fact, however, because it is well known that before the Seamen's Act was adopted American vessels were at a disadvantage in competition for world's trade.

What the Seamen's Act really does is to place added burdens upon the American ship which are not applied to foreign vessels, and, while it should be materially modified, there are certain humane features which should remain undisturbed. I am confident that shipowners generally will approve of this policy.

Those features of this Act, however, which have met with the greatest opposition from shipowners and which have caused the greatest hardships are the language tests, able seamen requirements, the excessive requirement of lifeboat men and the frequent payment of wages to seamen in foreign ports.

Section 14 of the Act, which relates to life-saving equipment, was taken from the regulations of the International Conference on Safety of Life at Sea. These regulations were intended primarily to apply to passenger vessels engaged in trans-oceanic trade. The application of these stringent requirements to our small coastwise and inland vessels has reduced their passenger allowances, ultimately forcing several of these companies to suspend operation.

It has been earnestly recommended by the Shipping Board Committee that Section 13 of the Seamen's Act be so amended that the extreme requirement of three years' apprenticeship for a rating as able seaman be reduced to a reasonable period so that this manifest discrimination against young Americans may be eliminated. It is well understood that this requirement of three years was craftily put into the law by the International Seamen's Union, with its 90 per cent of foreign membership, so that Americans might as far as possible be discouraged from going to sea, and berths on American ships be left to be monopolized by aliens.

Continuous Discharge Book.

Another important recommendation of the committee affecting the seamen's law and the seagoing personnel was one in favor of the introduction into the American service of the Continuous Discharge Book, with its record of the conduct and efficiency of seamen. It has long been in use in the British and other foreign services. This book has already been given out by the Pacific American Steamship Association with marked success and will be utilized also by the American Steamship Owners' Association.

So long as any usable part of the government-owned fleet remains in the possession of the Government it will act as a damp blanket on the hopes and plans of American shipowners and operators and also American shipbuilders. There is good reason to believe that, if the now proposed Shipping Bill is enacted, a very large proportion of the good Shipping Board tonnage can be disposed of within two years. American owners and operators very earnestly desire the continuous withdrawal of the Government from vessel ownership and operation until the government-owned fleet is entirely disposed of by sale or scrapping at the earliest practicable date. This is a first essential of the firm development of our merchant marine.

Until the fleet can be disposed of there can be no objection to the maintenance by the Shipping Board of essential ocean services non-competitive with private enterprise. But this situation must be handled very carefully so that private plans may not be blocked. Every effort ought to be made by the Shipping Board to turn every one of the essential services over to private ownership and management at the earliest possible moment. Many operators dread more than foreign competition even the faintest risk of the competition of their government.

Let me emphasize the truth which all practical men of our industry realize, that the government-owned fleet can never be sold until ample national aid is provided for the operation of those ships after they have passed into the hands of those who have the knowledge and the means to use them. Absolutely vital to the success of the American shipowning and operating industry is the prompt passage of the great Shipping Bill proposed by President Harding. If that fails, everything is lost that has been done toward a permanent restoration of American shipping in the overseas trade. If that fails, the American people lose all hope of realizing anything on their $3,000,000,000 investment in the shipping business. The national importance of this measure cannot be overestimated. Our foreign competitors are anxiously watching the result of the present legislative effort in Washington. They know as well as we know that this bill, once enacted, will make America a great commercial power on the seas. They dread the result of national aid applied to shipping exactly as it has been so successfully applied in the past to manufacturing, mining and farming in America.

As President H. H. Raymond of the American Steamship Owners' Association declared recently in his address before the joint Merchant Marine Committees of Congress in Washington:

"Either this present bill must be promptly enacted, or the United States in defiance of sound business, and in defiance also of the instinct and conviction of the vast majority of its own citizens, will be committed to a policy of government ownership and operation in the shipping business, and worse than that, to a policy of governmental subsidized competition with American private capital and enterprise. Such an unjust policy as this would not be tolerated for a moment by manufacturers. It would not be tolerated by agriculture. It should not be imposed on the merchant marine."

All American shipowners and operators will heartily approve this declaration.

The pending shipping measure offers substantial aid to every branch of our merchant marine. It proposes that 50 per cent of the immigration into this country be reserved to American ships. This of itself will be a most powerful help to the regular mail, passenger and cargo lines of transatlantic steamers. Another feature of the bill is the deduction from income taxes of shippers of 5 per cent of the freight money on goods exported or imported in American vessels. Though this will not directly benefit the shipowners, it will offer a strong inducement to shippers inward and outward to prefer the American flag and will thus assist to give American ships the full cargoes so necessary to profitable operation. Exemption of net earnings of American ships in the foreign trade from Federal taxation, if the amount of the exemption is pledged to the building or purchase of new ships, will encourage shipbuilding and increase the active merchant marine. The construction loan fund of $125,000,000, while costing the Government nothing in the long run, will promote the building of new tonnage of superior character.

Very important is the provision in the new bill that will make it possible to secure more

liberal allowance for depreciation for shipping, thus placing us more nearly on an equality in capital costs with our competitors. President Harding's policy of prompt diversion of the army and navy transport services to the merchant marine is made possible in the new legislation. An extension of the coastwise law to the Philippines is certain to have the same beneficial effect on shipping and trade as the extension of the coastwise law to Porto Rico and Hawaii.

What shipowners and operators are probably thinking most of, because they can measure its advantage in dollars and cents, is the direct aid of the new bill in the form of compensation or encouragement to both cargo ships and mail ships. This is the feature of the new proposal that is most actively discussed. It is the part of the bill that must meet the sharpest opposition. But let nobody imagine that this direct compensation was put into the bill to be pulled out again. Without the direct aid of the proposed compensations or subsidies, the great effort of the nation to solve its shipping problem cannot and will not succeed. The indirect aids are themselves inadequate. If the nation is going to help its shipping it must help it effectively and not place it half-way on an equality with its overseas antagonists. Nothing less than complete action will suffice.

We recognize frankly that, though we need all this entire measure of government help and can do nothing of ourselves without it, nevertheless we cannot lean on government aid alone. Given all these improved conditions, the problem of the American merchant marine must, after all, be actually worked out by American shipowners, operators and builders through their own exertions. We must win our own success, achieve our own destiny. We must be quick to distinguish and adopt the newest and best ideas of ship design and construction. We must operate our ships with the utmost possible enterprise and economy.

Uncle Sam is not a Santa Claus. He is giving us no gift, no bonus, in this shipping legislation. All he does is to try to assure for us a fair, even chance in competition. A fair chance is something which we have not had for sixty or for seventy years. If this bill passes, we will have it, and then it will be up to us to make such use of it as was made by the shipowners, operators and builders of the brilliant half century before the Civil War. They were given a chance. They took it, and they made such glorious use of it that the maritime world has not yet forgotten the years when American ships embodied the highest efficiency and success the world had ever seen. What we will have to do now is to prove ourselves as good men as our predecessors in this industry.

DISCUSSION.

THE PRESIDENT:—We all thank Mr. Smith for his kindness and courtesy in reading this valuable paper, and it has given an opportunity to any who had not read it before coming here, to go over it carefully and see exactly what the paper covers. It is thoroughly in line with the speeches that we heard at the dinner and is on the most important matter for all of us, as shipowners, ship operators and builders, namely, what to do to bring about the revival of the American merchant marine.

The paper is now before you, gentlemen, and open for discussion, and I hope that there may be a good many who will feel that they wish to say something in discussing the paper.

CAPTAIN C. A. MCALLISTER, *Member of Council:*—Mr. President, I wish to offer a resolution at this stage of the proceedings, that this Society go on record as favoring this proposed legislation; and I move you, sir, that you appoint a committee of three to draft a resolution to be presented at the end of the meeting, favoring the adoption of the bill.

THE PRESIDENT:—Favoring the adoption of what is called the American Merchant Marine Act of 1922?

CAPTAIN MCALLISTER:—Yes, sir.

The motion was duly seconded.

THE PRESIDENT:—Gentlemen, you have all heard the motion of Captain McAllister, that a committee of three be appointed to draft resolutions to be presented at the close of the meeting, so that they can be voted on, and we will all know just what it is we are approving to be sent to the committee considering the American Merchant Marine Act, heartily approving that act.

Are you ready for the question? Those in favor will please say aye. (Ayes.) Opposed, no. (No response.) It is unanimous.

The Chair appoints Captain McAllister, Mr. George A. Anthony and Mr. Charles F. Bailey as a committee, if they will withdraw and prepare the resolutions.

MR. R. W. ENGLAND, *Associate:*—I would say, gentlemen, that on the Great Lakes we are working on the same program that you appear to be working on here. The Lake Carriers Association in particular has taken it up, and I have heard the same thing in this paper tonight that we have been thrashing over the last month.

I came here to see the big ship today, as an operator; I am neither a constructor nor an engineer. This is the last thing I expected, to be able to say anything here. I thank you.

THE PRESIDENT:—Captain, I ought to say perhaps, for your benefit, this Society is not composed solely of engineers and naval architects but also of shipowners and ship operators. One of the primary designs of the organization of the Society was to bring together all the people who are interested in shipping, because while the men who started the Society were the builders of the ships, they realized that unless there are shipowners and operators there will not be any shipbuilders. So that you are perfectly at home here as a ship operator in our Society.

The paper itself is admirable, and it may be considered that it covers the subject thoroughly; but our feeling here always is that when a good paper is read, even if nobody has any fault to find with it, at least a good many will get up and say how well they think it has been done and call attention to same of the good points.

MR. H. C. TOWLE, *Member:*—Mr. Chairman, I did not come here with the intention of making any remarks, but I cannot resist giving expression to one thought that has always occurred to me when shipowners or shipbuilders talk about times previous to the Civil War. I have had the fortune to be acquainted with some of the gentlemen who were connected with shipping at that time, and there are some things that stand out very conspicuously to me.

The first is, that at that time most of the ship operators actually superintended the building of their own ships. If a captain wanted a new vessel, he either dealt with a builder who was thoroughly familiar with his trade or he stayed right on the job and got what he wanted.

Secondly, when it came to trading, most of the captains at that time, as far as I can find out, did their own buying and their own selling. For instance, they sailed their ships to China with a cargo from the east coast, traded it out there and brought back a cargo which they sold on this side; the point being that at that time the captain of the vessel, who was in many cases the majority owner, was in touch with all phases of the shipping business, the building and the operating and the trading.

I think that one of our troubles today is that we have got very far away from that. I speak as a shipbuilder, and one of the biggest problems we have to deal with in the shipyard is to find out what the ship operator really wants, or what the trade really demands. In many cases we cannot come to any agreement of minds. Something that the captain of the ship wants or the owner thinks he wants is something that is extremely expensive to build, and while I am not competent to speak from the operator's standpoint, I must say that often I cannot see where the capital expenditure involved will ever return any adequate percentage on the investment.

Of course there are exceptions. One of the most successful lines that we ever had on this coast, a concern that for five years earned something over 40 per cent on its capital investment, came to a shipyard and absolutely put the design and construction of the vessel up to that yard to work out to suit the operating conditions, as well as the construction details. The result was that the personnel of that shipyard got on the job, and among other things invented new methods of handling cargo, the net result being that the vessel carried every voyage 1,000 tons more cargo than a similar vessel of the same size and speed owned by a competitor. That thousand tons of cargo each voyage meant 40,000 tons more cargo a year, and made the difference between 5 per cent that other operators earned and 40 per cent that this particular line earned.

I merely cite that as an outstanding case, where to my mind all parties got together to achieve a result. I have no complete solution to offer, but I do think it is necessary to bring the three branches of the business closer together. (Applause.)

Mr. Alfred Gilbert Smith, *Associate*:—In order to possibly encourage others who can, I am sure, speak intelligently and very interestingly on the various subjects that have been covered by the paper, I will start and say two or three things, just for the sake of saying something.

You have heard at our dinner from our very able congressman, Mr. Edmonds, something with regard to the consular reports that he had read. He said he had many consular reports, tending to show that the fault was very largely—I am alluding to the troubles that ship operators and owners experience with their crews at times—the fault of the captains.

I have no doubt that what he says is absolutely true; he has those reports and the reports are doubtless correct; but I want to point out that the consular reports do not give information with reference to the troubles that occur on board the ships either going or coming, with which officers themselves deal, leaving the matter to be settled when the ship returns to the home port and where the owner or operator, based on experience, handles the thing by simply discharging the crew and getting another, or dismissing the offending man and getting another. Those things are not matters of record, and that is very unfortunate, be-

cause our legislators are governed somewhat by the consular reports, cases that are reported to the consuls at the out-ports, and not by many, many cases, the great majority of them, which are handled by the captains themselves or the chief engineers or other responsible officers, and dealt with by the owners at the home ports.

Another thing I think that operates against the owner and operator very largely is the lack of proper support on the part of some of the shipping commissioners and the leniency of the courts. It is very difficult to cover these matters by speaking of them broadly—at least I am not able to do so—but I would like to give you this one incident as an illustration:

Some time ago, one of our vessels in a foreign port, about to sail with a full complement of passengers and cargo, had this experience. One of the men on board (a sailor who had gone ashore without permission three or four days before) had spent the money that he had demanded from the captain before he went ashore, and had spent it riotously on shore. When he returned to the ship he was insulting, profane and obscene in his language, and one of the officers attempted to quiet him, whereupon he knocked that officer down. Another officer came and overpowered and secured him and, still struggling, they put him in the brig. The ship brought him home. The captain reported the case on arrival here to the proper officials and handed the remaining part of his wages to the commissioner. The offending man was held by the court for trial. The outcome of the trial was that the judge, after listening to the complaint said, in substance, to the culprit:

"Now, you did wrong and you know you did wrong. Don't you ever come before this court again on a charge of this kind. The case is dismissed."

Well, a month or two after that the vessel was in New York, all cargo had been loaded, the passengers were on board, and she was about ready to sail when two United States marshals walked on board. They went up to the bridge and said: "Captain, you are under arrest." "What for?" "The judge will tell you; you come along with us."

The captain left. The superintendent of the line accompanied the captain. They went to court. The judge, in substance, said:

"Captain, I am very sorry, just as you are about to depart with your ship, to do this, but I have no redress. This is the law. Charges have been brought against you by a man whom you had on your ship a month or two ago, of cruelty and false arrest. What have you to say?"

The captain explained the situation and, bail having been furnished to secure his appearance for trial, he was released and sailed after his ship had been delayed for an hour or two.

Subsequently, when the case was tried in the courts the captain was also dismissed by the presiding judge.

Now, this case that I have briefly outlined serves as an illustration of many similar cases that go before the courts, in dealing with a certain class of men, and that is, in my judgment, what has brought about existing conditions—at least on many American ships.

Take, for example, the provision of the La Follette Law that forces us to give to the men a certain portion of their wages at out-ports. Many of you gentlemen who have traveled know what some foreign ports are and what temptations they offer a man. The men go ashore, become intoxicated (and worse) and return to the ship not only drunk but they also bring disease with them, and they are unfit to do their work. The result is that they not only do not and cannot perform their duties on board ship, but they force their comrades—who remained on board and attended to their duties—to assume the labors of the disabled mem-

bers. What redress have we? Apparently, none whatever. Through one excuse or another, on this or that technicality, offenders get away with it.

One thing has been said, I think, in the paper that I have read here this evening for Captain O'Donnell, and that is the necessity which exists for captains to be better instructed, better informed with regard to their duties, their obligations, their rights, their privileges, etc., in the overseas trade. Up to within recent times you know that our merchant marine has been very largely in the coastwise trade; in such they have not the problems that men in the overseas trade have. The captain of an ordinary coastwise ship is given his cargo at the port of departure, and when he reaches the port of destination he simply turns the ship over to a terminal superintendent and his job for the time being is finished.

But the captain of a vessel in the overseas trade has a great deal more to do than that. He has to be familiar with the laws of the country that he is visiting, he must be well informed as to insurance matters, questions of general average, for instance, and numberless other matters that cannot be detailed here. There are many, many things that a master should know, and I for one deplore the fact that there are so many captains who are not sufficiently informed to enable them to do the right thing, not only for the owners but for the underwriters and others interested as well; in a word, for all concerned. To that end efforts have recently been made to prepare textbooks that can be handed to the captains so that, if they are industrious and care to read and improve themselves, they may be of value to them. In that respect I think the captains of steamers belonging to foreign countries are better informed by training and experience than our own masters, and I suppose it is a question of time when our masters will profit too as our merchant marine develops.

Another thing that has been said in this paper relates to one of the recommendations made by the committee of which I had the honor to be a member, the Committee on the Revision of the Navigation Laws, requiring duly qualified engineers on board ships to be experienced in making repairs; in other words, that they should have had some training in shops before they go aboard. I think that is generally the practice with British engineers. They have an engineer in fact, a man who knows not only the practice but also the theory of engines, and he has a number of assistants who are very experienced mechanics; so that if anything happens on board the ship while at sea, they can quickly perform the necessary repairs and she can go about her business. That is another thing that must be developed, in our judgment, and I hope that it will come to pass in due course.

The President:—I am sure we are all very grateful to Mr. Smith for his discussion. He is a man who speaks from practical experience as a manager of a very large line of steamers.

There is another gentleman here who knows this subject through and through; he has given as much attention to it probably as anybody else. I will ask Mr. Winthrop L. Marvin if he will say a few words to us.

Mr. Winthrop L. Marvin, *Associate*:—Mr. President, my friends of the Society of Naval Architects and Marine Engineers, I can testify that the paper which President Smith has read to you this evening, the paper prepared by Captain Eugene O'Donnell, of Boston, who regrets very keenly that he cannot be here in person this evening, sets forth with great accuracy the sentiment of the practical shipowners and operators of the American Steamship Owners' Association, of which Captain O'Donnell is one of the most active members, through his service on the Governing Board and for a long time as chairman of our impor-

tant Committee on the Seagoing Personnel. The captain in his paper lays emphasis, as I am sure we all in our thoughts lay emphasis, on the great Shipping Bill now pending in the Congress of the United States. I imagine that not one of us regards that as a wholly perfect measure, looking at it from our own separate standpoints, but I am very sure that all of us agree on this, that with its faults and its lacks, it is the very strongest and most satisfactory measure of legislation ever presented for the permanent upbuilding of the merchant marine.

The bill has been, as you know, the subject of long hearings. It will pass in a few days into the hands of the House Committee on Merchant Marine and Fisheries, a leader of which, Representative Edmonds, we have listened to with so much pleasure and so much instruction tonight. I imagine that that committee of responsible legislators, thoroughly versed in the shipping question, may make some changes in detail in that measure, may improve that measure, make it more workable and politically stronger, because they know far better than we know the political aspect of this question of the merchant marine.

On that bill, gentlemen, there hangs the fate of the ocean shipowning and shipbuilding industries of the United States. We are having or will have soon our day in court in Washington. It behooves us all, as men identified with these maritime industries, to acquaint ourselves thoroughly with the provisions of the measure when it appears again in its perfected form from Mr. Edmonds' committee; and it behooves us as citizens to see to it that all of us, every one of us, gives the fullest possible support as citizens to that measure while it is under consideration in the House and Senate.

It has been well said here, in the course of the address presented to you, and well said by President Raymond of the Shipowners' Association, that that measure, if it succeeds, if it becomes a law, is destined to be the Magna Charta of the new American merchant marine.

Most of you here this evening are identified with the shipbuilding industry. I can assure you that that bill means as much for you as it means for us, who are identified with the navigation of ships. I am betraying no secret, I am simply stating a fact that I know is known to you, that a great many of the American shipowning companies have very active and well advanced plans at this time for extensive and valuable shipbuilding. Those plans hang in a measure on the success of this pending legislation. I find that even our coastwise companies, our companies engaged entirely in the domestic trade, are waiting to see what happens to this Shipping Bill for subsidies and other aid to shipping in the foreign trade, before they close their contracts for coastwise steamers.

Of course, on the fate of this legislation hang absolutely all plans for larger steamers for the overseas trade. And under this bill, while it may take some time to get out of the way the very large volume of government-owned shipping, it is only a question of time and not a question of many years, nor even a few years, before the great shipping companies engaged in commerce overseas will be going to your yards to build a fleet of the finest steamers ever launched under the American flag.

We realize better than the outside public does, better than the legislators do, that this tonnage of the Shipping Board, valuable though it is in the development of our merchant marine, is not a satisfactory fulfillment of an effort to make that merchant marine again symmetrical and worthy of the American nation. The ships that shipowners will build, if left to themselves, are not in the government fleet today; they are not included among the hastily war-built tonnage. The ships that will distinguish the American merchant marine, if we get that American merchant marine going in earnest on the ocean, are ships of a higher

type, a far higher type than those included in the tonnage the Government has to dispose of. Left to themselves, our shipowners would gradually supplant the small and relatively crude tramp type of ships by larger vessels of the liner type, of greater speed and of greater cargo-carrying capacity. Left to themselves, they would build many more passenger and cargo liners of a superior class, of a type of which we have too few. And left to themselves, in the fullness of time they would turn to the building of the finest ships engaged in that great passenger trade across the Atlantic Ocean.

The promise for shipbuilding in this bill is very great. The bill in a measure comes just as closely home to you as it does to us. If the bill is enacted in complete form, I believe that ten years hence will see the United States firmly established as the foremost shipbuilding nation in the world, not necessarily in the bulk of its product, not necessarily in the aggregate of the amount of tonnage launched year by year, but in the quality of the tonnage and in the value of that tonnage combined.

I am glad to see, Mr. President, that so many members of this Society are comparatively young men, with their years of achievement before them. You have in this great measure pending in Congress an opportunity to enter upon a professional career of the very greatest honor and the very greatest profit and advantage. I know that, and I can speak of it, because I see many of the shipping executives—I see all of them in the course of a brief time. I can say to you with authority that this is not a shipowner's bill, but it is a shipbuilder's bill equally. We have a chance as citizens, all of us—shipbuilders possibly more than shipowners, because the shipbuilders have behind them a great mass of labor, which politicians respect because of its votes, a great mass of labor that ought to be heard here on the issue now pending in Congress. Boards of Trade and Chambers of Commerce in the country, from the National Chamber down, have spoken; the seamen on our ships, the American seamen, have spoken for this bill; but I am very much disappointed that as yet no voice, so far as I have heard, Mr. President, has come from the thousands of workers in our shipyards. And my message to you, gentlemen of the shipbuilding industry of the United States, is this—that you lose no time in organizing the intelligence and the self-interest of your workingmen, and putting that power behind the legislation which Representative Edmonds and his colleagues will soon be championing in the lower house of Congress. Let shipyard labor be heard, and heard at once. (Applause.)

THE PRESIDENT:—I cannot forbear to say, gentlemen, that it is a rare thing for us to have such an eloquent address as we have just listened to from Mr. Marvin. As Captain Dollar said tonight, he was a worker and not a talker, and with most of us the training in oratory has been slight, so that our speeches as a rule lack that elegant finish which we have just had so much delight in listening to from Mr. Marvin.

The hour is getting a little late now, and I see that the committee has returned, and I will ask Captain McAllister to come forward and read the resolutions which I presume that, with their usual efficiency, they have prepared.

CAPTAIN MCALLISTER:—Mr. President and gentlemen, the committee unanimously decided to submit this for your consideration:

Resolved, That the Society of Naval Architects and Marine Engineers, at a special meeting held in New York on May 19, 1922, having discussed the bill now pending before the

Congress of the United States known as "A Bill to Amend and Supplement the Merchant Marine Act of 1920, and for other purposes," desires to go on record as heartily favoring the early enactment of this measure into law.

This Society considers it of vital importance that our country place itself in a position to carry its surplus products to competitive foreign markets in ships owned in America and of American registry, as a matter of prudence and economy, in time of peace, and as a measure of national defense in time of war. Be it further

Resolved, That a copy of this resolution be forwarded to the President of the United States, and to the Senate and House committees having jurisdiction of the pending measure.

THE PRESIDENT:—Gentlemen, you have heard the resolutions. Does anybody desire to discuss them, or to suggest any amendment?

MR. ROBERT F. HAND:—Mr. Chairman, it may be rather presumptuous on my part to make any suggestion in regard to this motion, as I am here as a guest and not as a member of this Society; but as the resolution is worded it would indicate that this Society is in favor of these bills as now written. My suggestion would be that the Society goes on record as favoring these bills in principle.

THE PRESIDENT:—I think that is understood. No one can know now what the details of the bill will be when it comes out.

MR. HAND:—That is very true, but in the discussion this evening and in Captain O'Donnell's paper, no mention is made of the part of the industrial owner; that is, the shipowner that carries his own cargo; and there is a very marked discrimination in the bill against those owners, and I would like to see something in that resolution that the subsidy or the aids embodied in these bills be extended equally to all types of ships, irrespective of the ownership.

THE PRESIDENT:—I must say that I do not agree with you, sir, in this respect. I have been through this very same experience that this committee has had, as a member of a similar committee in another organization, to draw up resolutions, and we were met by exactly that same kind of question. One member of the committee right away said he did not agree with certain detailed features of the bill. I said to him, well, if we start out by saying we approve the bill except certain things, and we would like to have something else done with those, that would just ruin the whole effect of what you say. To me this resolution clearly means that we approve the bill in principle; we know perfectly well it is going to be modified.

MR. JOHN L. BOGERT:—Mr. Chairman, I move you that the report of the committee be accepted as it has been read, and that it be the sense of this Society and adopted as such.

MR. MASON S. CHACE:—I second the motion.

THE PRESIDENT:—Gentlemen, you have heard the resolutions and you have heard the motion to adopt them. If there is no further discussion, all those in favor will please say aye. (Ayes.) Good and hearty now; those in favor say aye. (Ayes.) Opposed, no. (No response.) The ayes have it unanimously, and the resolutions are adopted.

Gentlemen, I want to express my personal gratification at the success of this meeting, and I am sure that I can say the same for Mr. Cox. Of course, you all know that in all societies of this kind the work is really done by the secretary. The president is an honorary character, who is allowed to come before the meeting and say a few words and that sort of thing, but the real work is always done by the secretary, and I know that it must be a great delight to Mr. Cox to see how successful this meeting has been.

So, if there is no further business, we will now adjourn until our annual meeting in November.

Whereupon, at 10.18 p. m., the meeting adjourned.

THIRTIETH ANNUAL MEETING OF THE SOCIETY, HELD IN THE AUDITORIUM OF THE GRAND CENTRAL PALACE, NEW YORK CITY, NOVEMBER 8 AND 9, 1922.

INTRODUCTORY PROCEEDINGS

MINUTES OF THE THIRTIETH ANNUAL MEETING OF THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS, HELD IN THE AUDITORIUM OF THE GRAND CENTRAL PALACE, NEW YORK CITY, WEDNESDAY AND THURSDAY, NOVEMBER 8 AND 9, 1922.

FIRST SESSION.

WEDNESDAY MORNING, NOVEMBER 8, 1922.

The president, Mr. Walter M. McFarland, called the meeting to order at 10.30 a. m.

THE PRESIDENT:—Gentlemen, the meeting will please come to order. The secretary-treasurer will present his annual report.

REPORT OF SECRETARY-TREASURER.

The secretary-treasurer, Mr. Daniel H. Cox, in presenting the report, said: "Gentlemen, the report has already been distributed. It is prepared in the usual form. We generally do not read it *in toto*, but refer to the items that are of general interest to the members of the Society, making comparisons from one year to the other, so that you can see how the affairs of the Society are being conducted and what its status is."

NOVEMBER 1, 1922.

To the Council of The Society of Naval Architects and Marine Engineers:

GENTLEMEN:—I have the honor to submit the following report showing the condition of the Society at the close of the fiscal year ended October 31, 1922.

The membership of the Society as at October 31, 1922, was as follows:

Class of Members	Membership October 31, 1921	Elected at 1921 Meeting	Promotion Associate to Member	Promotion Junior to Member	Promotion Junior to Associate	Membership at Close Annual Meeting, 1921	Deaths 1921-1922	Resignations 1921-1922	Suspensions 1921-1922	Reinstated 1921-1922	Membership October 31, 1922
Members	1212	91	+9	+6	...	1318	18	68	29	1	1204
Associates	388	22	−9	...	+1	402	6	43	16	...	337
Juniors	53	9	...	−6	−1	55	...	4	3	..	48
Life Members	18	...	...	...	...	18	..	..	...		18
Life Associates	8	...	...	...	...	8	...	...	...	...	8
Honorary Members	1	...	..	...	...	1	...	...	...	..	1
Honorary Associates	1	...	...	...	...	1	...	...	...	...	1
Totals	1681	122	...	...	...	1803	24	115	48	1	1617

Deaths (24).

Members (18).

Ayer, Arthur W.
Benson, Wilmon H.
Burnside, Edwin A.
Carter, George J.
Churchill, Creighton
Cop, Huibert
Dickie, James
Macfarlane, Andrew
Martin, Frank S.
Mason, Earl P.
Metcalf, Frederick
Muckle, M. R.
Naphtaly, Samuel L.
Palmer, Nicholas F.
Rogers, William S.
Seabury, Charles L.
Shields, John
Walker, Frank

Associates (6).

Crawford, John de M.
Donald, John A.
Faris, David D.
Hall, Richard J.
Keilholtz, Pierre O.
Sebree, Uriel

Resignations (115).

Members (68).

Abrams, James S.
Anderson, R. Earle
Bankson, Lloyd
Barry, Ralph E.
Beebe, Walt B.
Bisset, Guy A.
Blair, David
Bookwalter, Charles S.
Buerkner, Geheimer O.
Bull, Gould H.
Chandler, Lloyd H.
Cotton, Percy J.
Cornfoot, William
Cowles, Rupert C.
Crosby, Samuel B.
Crowell, Charles N.
Debes, Erland D.
Deming, Lucius F.
Dilks, Lorenzo C.
Essner, Eugene F.
Fargusson, Mark
Fromme, Harry E.
Gary, Howland R.
Hansen, Max
Hector, Detlof A.
Herrick, Dayton E.
Heyward, John B.
Hiatt, Frank M.
Homer, Arthur P.
Hoffman, Frederick
Jack, Charles P. M.
Jackson, Oliver M.
Keil, Melville H.
Lane, Carlton V.
Locke, William L.
Lonergan, James L.
McAllaster, Eugene L.
McDermott, Eugene F.
McGarvey, Anthony J.
Mattsson, A. George
Michael, Walter H.
Morse, Benjamin W.
O'Keefe, Joseph C.
Ortel, Roland D.
Patterson, Ernest O.
Putzel, Charles L.
Richard, Nicholas
Roberts, Thomas G.

Robertson, Alexander
Robinson, George C.
Robinson, Thomas B.
Schlabach, Ross P.
Salmon, Edward M.
Saunders, Herbert B.
Six, William L.
Smith, Francis B.
Stevens, John A.
Stewart, William H.
Sweeney, John M.
Touriansky, Gregory I.
Vassilieff, Leonard N.
Wallace, Lindsay H.
Wall, William L.
Warner, Frederick T.
Waterhouse, William E.
Williams, George H.
Young, Benjamin P.
Young, John

Associates (43).

Banks, Lewis R.
Beebe, Walter B.
Bentley, Harold P.
Bonsall, George H.
Borie, Adolphe E.
Bowles, Joseph R.
Chenoweth, Harry H.
Civalleri, Piero
Cooke, Benjamin C.
Cornell, Samuel H.
Creuzbauer, R. Walter
Cullers, William H.
Davis, Frank L., Jr.
Foley, Peter R.
Hawk, William F.
Hubbard, Chester D.
Hunter, Henry C.
Kelly, William L.
Kennedy, William E.
Lam, Von Fong
Laraway, Lester H.
Levings, Sherburne D.
Levy, John H.
Livermore, Harris
McCarthy, William B.
McGregor, John A.
Magor, Basil
Mason, John W.
Miller, Charles H.
Much, Rupert M.
Newberry, Truman H.
Palmer, Herbert M.
Robinson, Walter W. H.
Seaborn, Henry G.
Shafter, Reuben R.
Smith, Percy L.
Stockmann, Erling B.
Thompson, John
Tonnelier, John E.
Warner, Edmund L.
Wenk, Morris
Wright, William L.
Ziegler, Samuel J.

Juniors (4).

Aldrin, Edwin E.
deGanahl, Frank
Fisk, Kenneth
Krebs, Carlos

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

Balance Sheet.

October 31, 1922.

Exhibit "A."

RESOURCES.

General Resources:		
Cash in bank and on hand		$4,545.60
Certificate of deposit—Bank of America		9,000.00
U. S. Liberty Second Conv. 4¼% Bonds—$5,000		5,012.00
Accrued interest on above		73.79
Due from members		6,647.50
Accounts receivable—dealers, etc.		111.00
Publications inventory		5,501.02
Furniture and fixtures		1,034.58
Meeting 1922—expense prepaid		137.23
Total general resources		$32,062.72
Endowment Fund:		
Corporate Stock, City of New York, $7,000—4½s	$7,000.00	
Bonds $5,000 Brooklyn Public Market—3½s	5,000.00	
Bonds 4,000 Baltimore & Ohio R. R. Conv. 4½s	3,925.00	
Bonds 2,000 Morris & Essex R. R. 1st Ref. 3½	1,732.50	
Bonds 3,000 Central Pacific R. R. 1st Ref. 4s	2,651.25	
Bonds 1,000 U. S. Liberty First Conv. 4¼s	1,000.00	
Bonds 3,500 U. S. Liberty Second Conv. 4¼s	3,500.00	
Bonds 11,800 U. S. Liberty 4¼s	11,343.84	
Bonds 6,750 U. S. Liberty 4¼s	6,750.00	
Bonds 1,000 U. S. Victory 4¾s	1,000.00	
Cash in bank	1.64	
Total endowment fund		43,904.23
		$75,966.95

LIABILITIES.

General Liabilities:		
Annual banquet, 1922		$3,480.00
Membership dues, fees and volumes—paid in advance		110.00
Total general liabilities		$3,590.00
Present Worth:		
Endowment Fund	$43,904.23	
General Fund:		
Balance November 1, 1921	$20,938.84	
Net income for year, per Exhibit "B"	7,533.88	
Balance, October 31, 1922	28,472.72	
Total present worth		72,376.95
		$75,966.95

INCOME AND EXPENSES FOR YEAR ENDING OCTOBER 31, 1922.

EXHIBIT "B."

INCOME.

Dues accrued for year	$25,090.00	
Less amounts written off	2,612.50	
Net dues accrued (collected in cash $21,535.00)		$22,477.50
Annual banquet 1921		1,253.10
Publication sales		1,754.21
Pamphlets sales (net)		40.05
Interest earned:		
U. S. Certificates of Indebtedness	$200.81	
Certificate of deposit Bank of America	244.58	
Bank deposit	67.35	
		512.74
Donation returned—Engineering Industrial Congress, 1921		85.00
Cash receipts—not claimed		10.00
Total income		$26,132.60

EXPENSES.

Publications:		
Inventory—November 1, 1921	$5,272.52	
Preliminary papers—1921	2,045.12	
Volume No. 29—1921	7,537.46	
	$14,855.10	
Less inventory—October 31, 1922	5,501.02	
Cost of publication	$9,354.08	
Annual meeting—twenty-ninth—expense	1,211.86	
Special meeting—May, 1922—expense	128.02	
Rent	1,002.00	
Office salaries	4,469.96	
Office expenses	1,559.01	
Bank collection charges	10.69	
Printing year book, 1922	442.50	
Storage	116.66	
Transportation	167.84	
Society emblems	21.15	
Depreciation of furniture and fixtures—10 per cent on $1,149.53	114.95	
Total expenses		18,598.72
Net income for the year		$7,533.88

ENDOWMENT FUND—FOR YEAR ENDED OCTOBER 31, 1922.

EXHIBIT "C."

Balance November 1, 1921		$40,530.84
Interest Earned:		
U. S. Liberty and Victory bonds	$933.83	
Municipal bonds	490.00	
Railroad bonds	370.00	
Bank deposit	4.51	
Total interest earned	$1,798.34	
Membership, entrance fees	1,820.00	
Total income	$3,618.34	
Less: Bank commission charges	44.95	
Net income for the year	$3,573.39	
Deduct: Contribution to Engineering Societies Library	200.00	
Net addition to fund for the year		3,373.39
Balance October 31, 1922		$43,904.23

The financial statements and books of account have been audited by Secor, Ronder & Company, Public Accountants, 115 Broadway, New York, N. Y.

Respectfully submitted,

DANIEL H. COX,
Secretary-Treasurer.

THE SECRETARY:—With respect to membership, it has been the expectation of the Council and of the members generally, that as a result of two things, the increase in membership for the present and for the immediate future cannot be expected to be very great; in fact, it is considered if we hold our own during the coming year or two we will be doing well.

The reasons are these: In the first place, we had at the time of the war, and immediately thereafter, a very large increase in the membership, largely of persons who were only temporarily engaged in shipbuilding and its kindred activities. Many of these men have since taken up other vocations.

The other reason is the acknowledged unfortunate position of the shipbuilding industry as a whole, which, of course, has meant that many men who have been, and will always be, interested in shipbuilding, have had to give up their positions and find it difficult to meet their living expenses, and they have been forced to give up many privileges, among them being membership in the Society; but notwithstanding these facts, it appears that the membership is probably going to increase during the present year, which is very gratifying.

The first page of the report gives the membership as of this time last year, and as we come to the meeting. You will see that the overall difference is a loss of sixty-four, approximately. The applications before the Council, which will be presented to you in due time, will more than make up for that deficit. That is a satisfactory situation.

Turning to the financial situation, a statement of which appears on pages 40, 41 and 42, the general resources of the Society have increased by approximately $10,000 during the past year. That is brought about in two ways—one as a result of the gradual building up of the Endowment Fund, through its own interest on its investment, and the other is through the additions to the membership with consequent additional dues.

Our liabilities are somewhat less than at this time last year, and only nominal, being represented by cash in hand for purposes of expenditures which have not yet been made, namely, the banquet and the volume for next year.

The present worth of the Society is $75,966.95, whereas at this time last year it was $63,473.68, making an increase of present worth of $12,000. The statement of income and expenses, which, of course, measures the amount by which we either went ahead or the reverse, shows that during the past year there was an excess of income over expenditure of $7,533.88, whereas the corresponding figure of last year was $6,507.68.

The report is really self-explanatory, and gives in complete detail figures from which are made the above general remarks.

This report, gentlemen, has been audited by the Council and approved by them, and I may say further that we had a special committee of the Executive Committee visit the Bank of America, which holds the securities as custodian, and verify by actual inspection the statement as to the bonds, etc., on hand.

THE PRESIDENT:—The members are now requested to rise while the Secretary calls the names of our members who have died during the past year.

The Secretary then read the list of Members and Associates who have died during the past year, the members of the Society meanwhile standing with bowed heads.

THE SECRETARY:—I intended to call your attention to one matter in commenting on the report, which slipped my mind at the time, and that is the ever-important question of payment of membership dues, that is to say, the question of the members whose dues are in arrears.

The Executive Committee and the Council realize that there are many members of the Society at the present time who are unable, except with great inconvenience, to pay their dues. At the same time the affairs of the Society have to be conducted in a business-like manner, and there must be a happy medium, which we will follow in our action regarding delinquent members.

The general action which has been taken is this: The membership has been very carefully gone over in that respect in a series of letters. I may say that every member who has not paid his dues has been communicated with several times, and an effort has been made by the Secretary or his assistant to find out why these members have not paid their dues. Members who have shown no interest in the Society, and made no reply whatever to these letters, and who are largely in arrears, have been dropped from the roll of membership of the Society. There is, however, a very considerable membership still in arrears, the amount not being very much in excess of that of last year or the previous year, but still representing, as stated in the report, $6,647.50. Since the report was submitted, we have received $797.50, so we have now outstanding in dues, owing to us from those who are still retained as members, $5,850. In studying over that list, which comprises that deficit of nearly $6,000, there appears a number of members whose ability to pay is unquestioned, but whose failure to pay is probably due to inadvertence on their part. The Secretary would consider it a great personal favor if the members present would impress on their friends who may be among the delinquents the importance of payment of the dues.

President McFarland then presented his address.

PRESIDENT'S ADDRESS.

Gentlemen, this is the thirtieth general meeting of the Society, the first one having been held in 1893. During the twenty-nine years which have passed, the Society has grown from small numbers to a very respectable size. Our maximum membership has been more than 1,800, at the end of last year. Since then the naval holiday and the great falling off in overseas commerce has had the natural reaction on the shipbuilding industry, with the result that for the past year things have been very dull. This has been a serious matter for everybody connected with the industry, has caused great reduction in the working force at all the shipyards, and, consequently, has made it necessary for many of our younger members to look for work in other lines. This has led to loss of members and delinquency in the payment of dues. Perhaps all of this was to have been expected after such an upheaval as the Great War, but it is only the few who, in times of prosperity, look far enough ahead to provide for the hard times that are coming.

The question of supreme interest for all of us just now is the Shipping Bill which has been reported to the House by Representative Greene, chairman of the Committee on Merchant Marine, and bears his name. The vital element in this bill is the recognition of the duty of the Government to encourage the merchant marine, just as it endeavors to encourage other industries in the country by means of a protective tariff. This particular method is not applicable to shipping, which has to go out on the high seas and meet the competition of the entire world. It is one of the curious phases of human nature that so much importance is attached to names. The proposed assistance to shipping is a subsidy, or subvention or bonus, and these names, to many of our people, seem very objectionable. The protective tariff

acts in exactly the same way, but indirectly; and because a definite sum is not appropriated from the Treasury and the people pay their share of the bill individually in their purchases they seem to consider it something different, although the principle is the same.

It is very gratifying to know that earnest effort has been made to educate the people of the country, particularly in the interior where the great distance from the ocean and shipping interests has in the past made them indifferent if not hostile to any effort to assist the merchant marine. These educational efforts have resulted in favorable action by Chambers of Commerce, Boards of Trade, and other representatives of the citizenship of the interior, and these will, of course, have very serious weight with their representatives in Congress.

The President has shown a strong personal interest in the matter and has gone on record as favoring government help for our merchant marine. Under all these circumstances we have every reason to hope for favorable action by Congress with the resultant benefit to shipowners, shipbuilders and all who have any connection with the operation or building of ships.

The passage of this bill will be of great benefit to the country at large by providing an outlet for the great amount of idle tonnage under the purview of the Shipping Board. For more than a year past it has been heart-breaking to see the great fleets of the vessels built during the war laid up in the Hudson, Staten Island Sound, Jamaica Bay, and elsewhere, because they could not be operated at a profit. This is due, of course, in part to the general stagnation of world trade, but, when it is possible for operators so to utilize these vessels as to make money, there is no doubt that they will gradually all get into the service for which they are best adapted.

During the latter part of the war, the class of vessels known as "transports" was designed of reasonably high speed and large capacity. The government officials wisely called in help from some of the big operating companies in the design of these vessels, with the result that they were planned so as to be readily converted into passenger and freight steamers of the "liner" type. As a matter of fact the end of the war came before any of them were finished, so that they were completed for passenger and freight steamers. All of them are now in service and giving a very good account of themselves, being used on the lines to Europe and South America from Atlantic ports and to the Orient from Pacific ports.

It is also very gratifying to note that a considerable number (about 150) of the vessels built at the three great fabricating yards have been in service almost continuously since they were built and reflect great credit on the yards for the record they have made. I happen to be in close touch with the performance of a number of these vessels and therefore am able to speak with assurance of the good work which they have done.

For large powers and high-speed vessels the geared turbine now seems an established favorite. In the case of cargo boats, such as the ones spoken of above, a great many installations have given complete satisfaction, and there is probably little doubt that with proper care and management they are entirely satisfactory. The reduced weight and greater economy due to this type of machinery certainly are a strong recommendation.

The very high thermal economy of the Diesel engine has brought it into very serious consideration in these days of the necessity to save at every point. A recent statement gives the number of motor ships afloat at about 1,450, with about 180 under construction. Nearly all of these are moderate or small power, although the hulls are often of large tonnage. The growth in recent years has been from 290 afloat in 1914 to the number above. It can hardly be said that any one design has thus far been accepted as the standard, and many able designers are working along various lines in the effort to bring down weights and initial cost.

The use of oil as the fuel under boilers seems to increase steadily, notwithstanding the

predictions of a relatively early exhaustion of the oil fields. As long as the price is reasonable, the advantages of oil fuel are so many and so great that its increased use is to be expected. It is obvious also that, when necessary, the boilers can be readily converted at small expense to coal burners. Indeed, some far-sighted designers have this possibility in mind and insist that the furnaces shall be so arranged that, when the change to coal occurs, grates of ample area can be installed so that severe forcing will not be necessary. So far as can now be seen, the supply of coal is ample for the almost indefinite period.

The experience in the Navy with the electric drive on the new battleships has thus far been very satisfactory, a striking instance being that of the return trip of the Maryland from Rio de Janeiro to this city in September of this year where, after steady running at 19 knots for most of the trip, the speed was increased to the highest point, over 21 knots, for the last two days and everything worked admirably.

Another form of the electric drive, where Diesel engines are used as the prime mover instead of steam engines, is being tried out in some vessels of moderate size and power. The limitation of the Diesel engine to small powers per cylinder has, of course, thus far ruled it out of any installations of very powerful machinery.

Mention should be made of the sale of the wooden fleet by the Shipping Board if for no other reason than to have a record for reference in future years. It was necessary almost to give away these wooden vessels, but the action of the board was undoubtedly wise as they were simply an expense to the Government and would soon have been entirely useless. It is probable that the majority of experts in the shipping world have always considered that it was a mistake to build these wooden vessels. They were really the product of the hysterical condition resulting from the German submarine menace when it was felt that it was worth while to have anything that would float and carry food and supplies to the other side. This unfortunate expenditure of government money, not to call it waste, would serve as one of the many texts for a sermon on the necessity of building up our own merchant marine. If wise legislation had been in force for many years so as to provide an adequate American merchant marine, it is perfectly certain that none of these wooden vessels would ever have been built.

The program of papers for the meeting holds out the prospect of very interesting sessions and I am very sure that you will share my pleasure at the fact that one of these papers is to be by our Honorary Vice-President, Admiral Taylor, who has contributed so many valuable papers to the Transactions, but whose onerous duties as Chief Constructor of the Navy in recent years have prevented him from contributing any for some years past.

THE PRESIDENT:—The Secretary reminds me I have to advise you of a very important matter. As you probably are aware, if you are familiar with the Constitution and By-Laws of the Society, the election of the officers of the Society, except the President, is made by the Council, and at its meeting this morning, the Council elected the following officers:

Honorary Vice-President:—Joseph H. Linnard.

Vice-Presidents for the term expiring October 31, 1925:—Albert P. Niblack, Richard M. Watt, Charles P. Wetherbee, Harvey D. Goulder.

Members of Council for the term expiring October 31, 1925:—Charles A. McAllister, Theodore E. Ferris, Hugo P. Frear, W. L. R. Emmet, J. Howland Gardner, William J. Davidson, vice Joseph H. Linnard.

Associate Members of Council for the term expiring October 31, 1925:—Albert Gilbert Smith, Geo. D. Ali, vice Robert A. C. Smith, resigned.

Executive Committee:—Stevenson Taylor, Washington L. Capps, Andrew Fletcher, Frank L. DuBosque, Joseph W. Powell, Homer L. Ferguson, Albert Gilbert Smith.

Committee on Papers:—Frank L. DuBosque, J. Howland Gardner, Herbert L. Aldrich.

Secretary-Treasurer:—Daniel H. Cox.

Assistant Secretary-Treasurer:—Thomas J. Kain.

There is another matter, however, in which the membership itself does the voting, and that is the election of new members. The Secretary will now read the list of candidates for Members, Associate Members, and Juniors, comprising the names recommended by the Council, and passed on by them for election.

THE SECRETARY:—The following applications have been received in the grades enumerated and are recommended by the Council for favorable action of the members on the applications:

Members (46).

Frank E. Ames, Supervising Local Manager, Maintenance and Repair Department, U. S. Shipping Board, Gulf District. P. O. address: 816 Carondelet Building, New Orleans, La.

Jose Garcia de Arago, Lieutenant, Naval Constructor, Inspectoria de Engennaria Naval, Rio de Janeiro, Brazil.

Charles A. Auld, Surveyor, American Bureau of Shipping, Savannah, Ga. P. O. address: 306 Savannah Bank & Trust Building, Savannah, Ga.

Henry G. Avery, Chief Daughtsman, W. & A. Fletcher Company, Hoboken, N. J.

Joseph S. Bechtel, Surveyor, U. S. Salvage Association, Inc., Norfolk, Va. P. O. address: 211 W. 16th Street, Norfolk, Va.

P. Eskil Berg, Assistant Consulting Engineer, General Electric Company, Schenectady, N. Y.

George F. Blair, Manager, Operating Department, E. F. C., U. S. Shipping Board, Norfolk, Va. P. O. address: 459 Virginia Avenue, Willoughby Beach, Norfolk County, Va.

Edward Brough, Vice-President and General Manager, Theo. H. Rohde, Inc., Baltimore, Md. P. O. address: 110 South 5th, Brooklyn, Baltimore, Md.

James T. Christie, Resident Surveyor, U. S. Salvage Association, Norfolk, Va. P. O. address: 3500 Omohundro Avenue, Norfolk, Va.

Howard E. Cornell, Naval Architect and Engineer, Cornell & Matthews. P. O. address, 712 Bulletin Building, Philadelphia, Pa.

J. Marshall Cowell, Gibbs Brothers, Inc. P. O. address: 731 31st Street, Newport News, Va.

Jesse B. Crew, Engineer, New York Shipbuilding Corporation. P. O. address: 201 White Horse Pike, Audubon, N. J.

Lebbeus Curtis, Marine Surveyor, Pillsbury & Curtis, San Francisco. P. O. address: 2629 Etna Street, Berkeley, Cal.

Charles J. Fairbairn, Marine Surveyor and Superintendent Engineer, Esplen & Sons & McNaught, New York, N. Y. P. O. address: 408 77th Street, Brooklyn, N. Y.

Ralph T. Gordon, Sales Engineer, Alberger Pump & Condenser Company, 140 Cedar Street, New York, N. Y.

Robert S. Griffin, Rear Admiral, U. S. Navy, Retired. P. O. address: 2003 Kalorama Road, Washington, D. C.

William E. Griffith, District Director, U. S. Shipping Board, Emergency Fleet Corporation, Navy Building, Washington, D. C.

Roland F. Hill, Assistant Manager, Pusey & Jones Company, Wilmington, Del. P. O. address: 109 Bryn Mawr Avenue, Cynwyd, Pa.

Clarence C. Jacobson, Marine Designer, Department (Plant and Structure), City of New York. P. O. address: 476 Clove Road, W. New Brighton, S. I., N. Y.

Charles S. Joyce, Commander, U. S. Navy, Shop Superintendent, Machinery Division, Navy Yard, New York, N. Y.

William P. Kain, Chief Hull and Engineer Surveyor, American Steamship Owners' Mutual Protection and Indemnity Association, Inc., 49 Wall Street, New York, N. Y.

James L. Layton, Superintendent of Machinery, Todd Dry Dock and Construction Corporation, Tacoma, Wash. P. O. address: 219 N. Tacoma Avenue, Tacoma, Wash.

Rowland Linfield, Principal Surveyor, American Bureau of Shipping, New Orleans, La. P. O. address: 1029 Maison Blanche Building, New Orleans, La.

James D. Maxwell, Superintendent, Par Machine Works, Inc., Brooklyn, N. Y. P. O. address: 32 Fuller Place, Brooklyn, N. Y.

Charles M. McMillan, Purchasing Agent, Jahncke Dry Docks, Inc. P. O. address: 814 Howard Avenue, New Orleans, La.

Chester B. Mills, Chief Engineer, Sperry Gyroscope Company. P. O. address: 3905 Glenwood Road, Brooklyn, N. Y.

F. P. Noel, Traveling Inspector, U. S. Steamship Inspection Service, Department of Commerce, Washington, D. C. P. O. address: 416 Seward Square, S. E., Washington, D. C.

Reginald Paulsen, Estimator, Bethlehem Shipbuilding Corporation. P. O. address: Box 167, Bethlehem, Pa.

Harold D. Rice, Naval Architect, American Balsa Company, Long Island City. P. O. address: 143 East 235th Street, New York, N. Y.

Allan C. Robertson, Surveyor, Salvage Association of London, 68 Broad Street, New York, N. Y. P. O. address: 80 William Street, Hempstead, L. I.

John C. Rohlfs, Manager, Marine Department, Standard Oil Co., San Francisco, Cal.

William H. Sampson, Lieutenant (C. C.), U. S. Navy, Navy Yard, Boston, Mass.

Herman Scharnagel, Chief Engineer of Engine Department, Sperry Gyroscope Company, 40 Flatbush Avenue Ext., Brooklyn, N. Y.

John W. Shaddick, Chief Engineer, Coastwise Transportation Corporation, 160 State Street, Boston, Mass. P. O. address: 35 Chester Street, Allston, Mass.

Herman F. Smith, Superintendent Engineer, Union Sulphur Company, 33 Rector Street, New York, N. Y. P. O. address: 5680 Boulevard, North Bergen, N. J.

Eugene R. Spunn, Estimator, Bethlehem Shipbuilding Corporation, San Francisco, Cal. P. O. address: 2623 College Avenue, Berkeley, Cal.

David V. Stratton, New York Manager, Morse Dry Dock and Repair Co. P. O. address: Room 2723, Whitehall Building, 17 Battery Place, New York, N. Y.

William E. Swinburne, Underwriters' Surveyor, Salvage Association of London, 68 Broad Street, New York, N. Y. P. O. address: 50 New Street, East Orange, N. J.

Robert F. Townsend, Ship Broker and Marine Engineer, 17 Battery Place, New York, N. Y.

Otis D. Treiber, Naval Architect and Engineer, Atlas Imperial Engine Company, Oakland, Cal. P. O. address: 2515 Noble Avenue, Alameda, Cal.

Kenneth M. Walker, Naval Architect and Marine Surveyor, Seattle, Wash. P. O. address: 404-405 Central Building, Seattle, Wash.

Hugh B. Watson, Principal Surveyor, American Bureau of Shipping, Buffalo, N. Y. P. O. address: 812 Prudential Building, Buffalo, N. Y.

Henry D. Wight, Director and Manager, The Sanderland Forge and Engine Co. P. O. address: Sydenham Road Works, Belfast, Ireland.

William C. Williamson, Sales Manager, Briggs Bituminous Composition Company, Inc., 17 Battery Place, New York, N. Y.

Alfred B. Willoughby, Machinery Department, The Bourse, Philadelphia, Pa.

Felix Ziegel, 27 Rue Fortuny, Paris, France.

Associates (14).

Harold B. Chamberlain, Sales Engineer, Coen Company, 50 Church Street, New York, N. Y.

William J. Coogan, Sales Manager, American Marine Plant Company, 15 Moore Street, New York, N. Y.

Thomas A. Ensor, Marine Superintendent, Kerr Steamship Company, 44 Beaver Street, New York, N. Y. P. O. address: 163 Hicks Street, Brooklyn, N. Y.

Robert F. Hand, Assistant Manager, Marine Department, Standard Oil Company (N. J.), 26 Broadway, New York, N. Y.

John A. Hense, Eastern Manager, Northern Fire Apparatus Company of Minneapolis, New York, N. Y. P. O. address, 51 East 42d Street, New York, N. Y.

Lawrence D. Howell, Sales Engineer, Westinghouse Electric & Manufacturing Company, 165 Broadway, New York, N. Y. P. O. address: 44 Central Avenue, Tompkinsville, S. I.

William S. Lindquist, Chas. Ward Engineering Works, Charleston, W. Va. P. O. address: 271 Hicks Street, Brooklyn, N. Y.

Frank F. C. Ling, 153 N. Szechuan Road, Shanghai, China.

Robert G. Payne, Sales Manager, White Fuel Oil Engineering Corporation, 742 East 12th Street, New York, N. Y. P. O. address: 27 West 44th Street, New York, N. Y.

J. Harry Philbin, Manager Department of Ship Sales, U. S. Shipping Board, Emergency Fleet Corporation. P. O. address: 2625 North Charles Street, Baltimore, Md.

Durward H. Primrose, Managing Editor, *Marine Journal,* Liberty Street, New York, N. Y. P. O. address: 511 Twelfth Street, Brooklyn, N. Y.

Norborne L. Rawlings, Lieutenant (C. C.), U. S. Navy, Navy Yard, Norfolk, Va.

William H. Stayton, Sr., President, Baltimore Steamship Company, Baltimore, Md. P. O. address: University Club, Baltimore, Md.

Perry R. Taylor, Lieutenant (C. C.), U. S. Navy, Assistant Shop Superintendent, Navy Yard, Norfolk, Va.

Juniors (6).

Arthur A. Charlson, Instructor in Department of Mechanical and Marine Engineering, University of California. P. O. address: 4040 Oak Street, San Francisco, Cal.

John D. Crecca, Lieutenant (C. C.), U. S. Navy, Navy Yard, Philadelphia, Pa.

Joseph G. Hauber, Mechanical Engineer, Hastings Pavement Company. P. O. address: 390 Warburton Avenue, Hastings-on-Hudson, N. Y.

Daniel J. McAuliffe, Draughtsman and Estimator, Jahncke Dry Dock, Inc. P. O. address: 1039 Flood Street, New Orleans, La.

Albert G. Steltzner, Senior at the University of California, 766 Sutter Street, San Francisco, Cal.

Edward L. Young, Estimating Department, Staten Island Shipbuilding Company, Mariners Harbor, N. Y. P. O. address: 199 St. Marks Place, New Brighton, S. I., N. Y.

Transfer of Membership, Associate to Member (11).

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Junior to Member (3).

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G. Brick Smith, Chargeman, Hull Estimating and Design Department, Newport News Shipbuilding and Dry Dock Company. P. O. address: Box 665, Newport News, Va.

THE PRESIDENT:—Gentlemen, you have heard the list of names read by the Secretary as applicants for membership in the Society in the various classes which have been announced. All in favor of electing these gentlemen will say "Aye"; contrary-minded "No." It appears to be unanimous, and they are declared to be elected.

Before calling for the first paper, a radiogram has been received from Mr. Elmer A. Sperry as follows: "Please inform Naval Architects—Anniversary Congratulations to Japan Society of Naval Architects Enthusiastically Received—Bringing Responses." Mr. Sperry

has, as you have probably learned, been highly honored during his visit to Japan, being decorated with the Order of the Rising Sun, Third Class. He was also a guest of many of the technical societies and delivered a number of addresses. His radio was sent when he was near Honolulu on his way home and we expect him here about November 20.

As some of you gentlemen will recall, we were notified some time ago of a meeting commemorating the 25th Anniversary of the foundation of the Japanese Society of Naval Architects. Some of our members contributed papers for that meeting, including Mr. Sperry, and he attended the meeting. We took advantage of his going to send greetings to the Japanese Society of Naval Architects, in a rather more formal way than simply writing a letter. We prepared words of greeting which were gotten out in a nicely illuminated form, and they were taken by Mr. Sperry to be presented by him in person to the president of the Society. This radiogram from him shows that they were very much appreciated.

The first paper on the program is one by Mr. Elmer A. Sperry, E. D., a Member of the Society, and is entitled "Automatic Steering." It will be read by Mr. Mills, the chief engineer of the Sperry Company, and I want to call attention to the notice on the bulletin in regard to the presentation of papers and the discussion following, which is to the effect that members are expected not to take more than twenty minutes in presentation of the paper and not more than ten minutes in discussion.

Mr. Mills then presented the paper. After the reading of the paper and in conjunction therewith, he showed various slides.

AUTOMATIC STEERING.

By Elmer A. Sperry, E. D., Member.

[Read at the thirtieth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 8 and 9, 1922.]

The dearth of accurate knowledge with reference to the steering of ships is nothing short of amazing. A search of the literature in this and closely associated arts fails to reveal anything but the most meager reference to this important phase of ship operation.

Doubtless the very great difference in the behavior of ships and their response to helm under efforts to keep them on their course under conditions which to all intents and purposes seem identical indicates the impossibility of laying down any set rules and regulations looking towards standard performance. This certainly stands in the greatest contrast to the amount of literature available on the propulsion plant, propellers, stream line forms and middle body characteristics, etc., of ships. Thus the subject of the proper manipulation and performance of the steering and guiding apparatus of the ship has received almost no attention, while it has more to do with the ship's retardation and its ultimate performance as a whole than some of the factors on which a great deal has been written.

Recent contributions of no small significance have been made to our knowledge of this art by the fact that, thanks to the gyro compass, we are able to obtain continuous graphic records of high accuracy. Much of this record has been made with simultaneous graphic record of helm angle, making possible a searching investigation into the whole realm of response of seagoing craft to rudder and bringing in many other items touching general performance. This enables us to trace cause to effect and to observe just what each alteration in the mechanism has brought to pass in point of actual performance. Most valuable light has thus been thrown upon the whole art of steering ships, and especially has this been extremely useful in the perfection of automatic steering.

It has long been supposed that an efficient "iron quartermaster" would never be made, because it has been inconceivable that any mechanism could ever replace efficiently the species of intuition on which an expert quartermaster is supposed solely to depend for high efficiency performance. This seems to be corroborated by the fact that no two quartermasters seem to be able to steer, especially a large ship, with anything approaching equal efficiency. That intuition of the sort named plays only an insignificant part in proper handling of the helm was at a very early date shown by the very great improvement in steering by all quartermasters upon the substitution of the gyro for the magnetic compass.

The steering of ships, torpedoes, airplanes, dirigibles, etc., where the rudder is aft, presents several problems, some of which, at least, are due to the fact that the controlling of the direction of such a craft is in constant unstable equilibrium. This is evidenced by the constant tendency of all ships to yaw off their course.

That an instrument can be of material aid in the matter is shown by the fact that in the hands of almost any quartermaster a given ship often decreases its angles of yaw in a given sea from one-fourth to one-sixth by shifting from the magnetic to the gyro compass. As

is known, there is more or less lag in the operation of the magnetic compass on board ships, especially as they are built more and more of steel, with an ever-increasing necessity for compensation, which, in the last analysis, means neutralization and impoverishment of the lines of force reaching the magnetic needle. When the various factors of compensation have all been introduced, the needle, especially on large ships, is found to be very sluggish and slow to respond to the smaller changes of heading. This, in a measure, is the reason for poor steering on the part of most quartermasters. It is proverbial that a good quartermaster prefers to watch almost anything except the compass and, as a matter of fact, this is just what he does. He simply observes the compass now and then for course, but depends on outboard observations and ranges for suppression of yaw.

The main points that influence holding a ship on her course under service conditions are the following:

1. The general characteristics of the ship, especially as to flow of water to the rudder and the disturbances of the water by nearby propellers.

2. The general effectiveness of the rudder, as such.

3. Whether the ship is light or loaded and, when light, if she is low at the stern with large areas forward exposed to wind effect. A ship in the latter condition will require more "helm" with beam wind than with normal loading. The amount of helm required by different ships under the same weather conditions is found to vary considerably. Some require more helm than others to suppress yaw and keep the ship on her course. Some ships are known to be cranky and quickly tire the quartermaster, as shown by the poor steering record during the latter part of his watch. Other matters that influence steering to no small degree are currents and tides, and tide rips where the two meet.

Regardless of the particular brand of psychology which different quartermasters are supposed to annex in carrying on their work, it would seem that in the final analysis steering resolves itself into a comparatively few well-established maneuvers. Although it may seem difficult to characterize these, yet they resolve themselves into "easing off" and "meeting," terms sometimes used to express one form or another of true anticipation. It would seem next to impossible to so organize a mechanism that it could perform in any sense the function of anticipation, but, regardless of terminology, results have already been achieved, indicating that such performance can be secured most effectively.

If automatic steering is to be of the greatest value in controlling the ship's course, one of its paramount objects must be to suppress helm. The steering must be accomplished with the minimum of helm. I believe that only a few engineers and naval architects appreciate how great a resistance can be offered to the ship by even a small rudder angle, and it is this angle that must be suppressed. To do this, the act of anticipation becomes paramount, and the correction to course must be introduced long before an ordinary quartermaster would realize the necessity for change. This fact alone emphasizes the importance of a guiding element that is instantly and minutely responsive, to be employed as a base line so that the slightest departure from the course may be utilized to apply the correction.

No magnetic compass can ever be relied upon to do this. So difficult is this part of the performance that some workers have felt that they must go outside the gyro compass and introduce a quantity of highly organized and expensive auxiliary mechanisms for accomplishing the result. At least one worker has proposed to employ intricate gyroscopic elements as auxiliaries. All of these have been found unnecessary, inasmuch as within the last ten years ways and means have finally been developed that prove that in the gyro compass

alone, with its instantaneous response to minute deviations of course, we have everything that is necessary to accomplish the purposes most effectively, even including the "easing off," "meeting," and full anticipation.

Of course, in the case of the gyro compass it is not the master which is used direct. The master compass is usually mounted below decks. The repeater follows the master with an accuracy of one-twelfth of a degree. This minute accuracy with which the gyro compass repeater indicates the true course of the ship and the instantaneous response, being probably less than 1/100 of a second together with its great directive force, gives opportunity for automatic steering never before possible. In fact, it may be said that the gyro compass has ushered in the era of automatic steering.

The embodiment of the mechanism for automatic steering has been developed in two types, which may be known as the "separate" system, one example of which is shown in Fig. 1, Plate 1, and the "unit" system, shown in Fig. 3, Plate 2. In each of these figures the steering wheel is clearly to be seen in its ordinary position on the bridge. In Fig. 1 a properly magnetic shielded motor is shown above, secured to the ceiling. This motor, which in the "unit" system is contained within the pedestal, is reversible and under the control of the automatic contact devices operated by the joint movements of the gyro compass and rudder. This again receives modification from a device which constantly measures the yaw angle by means of which the anticipation and constant suppression of the yawing is accomplished. Either of these systems can be employed with any telemotor system, but we prefer the "separate" type where a telemotor is not employed. Fig. 2, Plate 1, shows the system mounted in the wheel-house of one of the largest tankers, the John D. Archbold, having a loaded displacement of 32,000 tons. The back end of the handle for throwing the automatic on and off is seen at *D*.

When the "separate" system is being employed, it is found that a self-synchronous, completely automatic helm angle indicator can be used without requiring an extra cable.

The method of operation of the automatic steerer or "iron quartermaster" is very simple. The instrument is capable of being set for response to different amounts of deviation from course. It has been employed practically for continuous steering of very large ships, and its quite remarkable performance is illustrated by conditions where the response is set as close as ten minutes of arc or 1/6° of departure from true course in azimuth. This operation is positive in its nature and through the closing of an electric contact calls into action the rudder operating mechanism, which simultaneously establishes the helm angle. This, in turn, operates a suitable follow-up mechanism by adjustment auxiliaries effecting the proper anticipation, and the helm "eased off" and returned or swung to its proper complementary angle. The effect of this manipulation is plainly to be seen in the records of Fig. 4, Plate 3. This particular record was taken as a result of automatic steering of a ship loaded to 32,000 tons displacement, Fig. 5 being a record of the steering of the same ship while light or in ballast. These two represent the most difficult conditions of steering that will perhaps ever be met with in one and the same ship, as this is probably an instance of the greatest difference possible between loaded and light conditions, in this case bearing a displacement ratio of 2.7 to 1. In her light condition she is low aft and with bow well out of the water, constantly carrying more or less "helm" when cross wind and currents prevail, yet the record gives evidence of the high order of steering secured.

Referring now to Fig. 3, Plate 2, the gyro-compass repeater is seen at the top of the

pedestal containing the automatic mechanism. The handle for throwing the automatic in and out of connection with the steering wheel is seen at *A* in the lower part of the figure. Near the top of the pedestal is shown the little tiller wheel *B*, by means of which all changes of course are set and, in fact, the ship is often steered by this little wheel through the automatic. The adjustments for steering with the least helm according to different conditions of the ship, light or loaded, and also weather conditions, are seen to the left of and below the little tiller wheel *B*. Any standard telemotor, indicated at *C*, may be employed with either equipment. All parts of the mechanism inside the pedestal are completely accessible from the back, and the gear from a door on the side of the forward conical projection. The mechanism is found to operate continuously day and night almost without perceptible temperature rise. The standard pedestals coming through for service on a number of ships are smaller than the one shown in Fig. 3.

With an experienced and highly skilled quartermaster and a gyro-compass repeater conveniently located, especially with the usual magnifying reading glass (seen in Fig. 2) near its card for ease in observation of minute indications, an accuracy in steering can be obtained that leaves practically nothing to be desired, with the possible exception that with automatic steering the frequency with which the helm is altered may be greater, and the "helm," as such, is employed to a higher degree of efficiency. By "helm" is meant a central position taken up by the helm for automatic neutralization of tide, stream and wind, from which slight departures only constitute all the steering necessary. This contributes directly to fuel saving.

Another matter that never fails of interest is the difference with the same helmsman steering by magnetic and gyro. A small part of such a record is shown in Fig. 6, Plate 4, on natural scale. Fig. 7, Plate 4, shows parts of a similar record on a scale magnified ten times. Here we have an adjacent section of the same magnified record showing a piece of remarkable steering by the same quartermaster brought about by the simple substitution of the gyro for the magnetic compass.

Fig. 8, Plate 5, is not without interest owing to the fact that it shows extremely good hand steering compared with a high class of automatic steering. This indicates that the hand steering by this particular expert quartermaster was a trifle better than the automatic. This is the upper line; in the lower line the same with another quartermaster, showing poorer steering by hand than with the automatic.

Fig. 9, Plate 6, gives a glimpse of how the studies referred to in the leading paragraphs have been prosecuted. This is a simultaneous record of helm angle and ship's heading by special magnified and quick moving reel, the chart amplitude of the latter being multiplied by 10, the helm angle by 3, and the time by 20. These magnified records are made by the operation of the automatic steering mechanism itself at sea. The perfection of automatic steering is here shown by the extremely small amount of yaw angle. This, being on the order of 1/3 of a degree only from the course, illustrates how ponderous masses can be brought under strict control.

It is the magnification of results like this that has taught us much during the perfection of the apparatus. Not only are wide angles of yawing and sinuous course *prima facie* evidence of bad performance in requiring a longer distance to be traveled on each leg of the course, but it involves bad angle of attack of the seas as compared with straight steering and a definite waste of propulsive power under each of the above counts.

If the best steering that can be done by magnetic is seen to make such a poor showing

in wide angle yawing of the ship itself, what will we say when we come to take a simultaneous record of the activities of the rudder, as in Fig. 10, Plate 6? Here we come face to face with the true evils of poor steering in constantly applying large amounts of rudder and running up fuel costs while making a poorer showing in headway. Compare the yawing angles of this record with the magnified records in Fig. 5, which are on the same scale. It should be remembered that each little step on the magnified chart is only 1/6 of a degree.

Fig. 11, Plate 7, is a very excellent illustration of the difference between the best steering that could be done by the quartermaster using the gyro in heavy weather and immediately throwing on the automatic. We are still dealing with magnified charts with the chart amplitude multiplied by 10. No better proof of the value of automatic steering can be asked.

Since we have been obtaining continuous precision records of the ship's steering performance, we have subjected some of them to mathematical investigation with the following results. These have been taken under two headings:

1. Helm angle.
2. Zigzagging or sinuosity of course.

Under the first heading the rudder resistance was investigated. The records show that when steering by magnetic compass, an average of 6 degrees of helm was held. When steering by gyro compass, this average angle was reduced to 1.93 degrees. With the rudder at an angle the rudder resistance is represented by the formula

$$R = AV^2 \times \sin \alpha \times p,$$

where A is area of the rudder in square feet, V is speed of the ship in knots per hour plus 20 per cent allowance for the slip, α is the helm angle, and p is the pressure of the water at speed of one knot, equal to 3.19 pounds per square foot.

Assuming the area of the rudder of the ship whose records were investigated to be 86 square feet, we have a helm resistance with the magnetic compass of 9,300 pounds, and with the gyro 3,000 pounds.

Turning now to the second heading, which is more important, by using the tangents of the angle, period, etc., for check, we find the very considerable extra distance that it is necessary to travel between given points, the angles also giving us some components of the extra resistance owing to the bad angle of attack and mean extra cross-section area forced through the seas. These lead up to results that check fairly well with large and worthwhile savings of both fuel and time between given ports. The demonstrations repeatedly made of the marked shortening of time over best previous performance has led a number of the largest ship operators to install complete gyro-compass equipments, thereby availing themselves of this latest refinement of automatic steering with its remarkable additional contributions.

The development work on this device first starting in 1913 has recently been mainly in the direction of simplification and the embodiment of very necessary reliability and ruggedness so essential in apparatus of this kind which will go into more or less unskilled hands, and which must be immune to vicissitudes of weather and sea effects. Sea trials have very conclusively indicated that great benefits and economies to be derived from automatic steering are now available in ships equipped with gyro compasses.

DISCUSSION.

THE PRESIDENT:—Gentlemen, you have heard this paper, No. 1, on "Automatic Steering," by Mr. Sperry. It is now open for discussion.

MR. ROBERT H. ROGERS, *Visitor:*—We will all agree that a continuous, insidious loss of fuel and time always goes with hand steering of ships.

Crude and simple records made on sea voyages of five ships are confirmed by the more refined methods of observations made possible by the various Sperry instruments operated from the gyro compass.

A continuous helm of 6 degrees is shown by Mr. Sperry in a specific case to set up a drag of 9,300 pounds. This would equal 356 tow rope horse-power, 500 brake horse-power, or 16 per cent of the available power of the ship's engines.

On a ship using 100 barrels of fuel oil per day, imagine the captain and chief watching sixteen barrels being poured over the rail every afternoon. That loss would be obvious rather than insidious. In addition, if the innumerable checks to the speed were concentrated into a dead stop of an hour and more each day, the matter would be thoroughly overhauled.

While there is a good reason for better hand steering to a gyro than to a magnetic compass, due to the former's quicker and more complete action on small angles, still the difference between the work of first class quartermasters and poor but still acceptable quartermasters is so great that the slight improvement possible in each case still leaves average steering a heavy source of loss.

On the twin-screw S. S. Virginia with magnetic compass in one hour, under precisely similar conditions, one quartermaster used 84 degree-minutes of helm while his successor used 254 degree-minutes, an increase to 300 per cent.

On the motor ship Missourian, with gyro compass, one quartermaster used 850 degrees total helm movement per hour with a maximum helm of 6.4 degrees, while another under the same conditions used 1,114 degrees, or over three complete revolutions with a maximum single angle of 16 degrees.

As Mr. Sperry states, yawing can be kept to a minimum when outboard ranges or observations are available to the quartermaster, who then only occasionally refers to the compass for the course.

The most accurate index of yawing, both as to instant of beginning and total amount, that I have found is in the simple expedient of referring to a fine line connecting the ship with a small drag towed in the wake. Such a line lies in the course made good, and its angle with the axis of the ship reflects accurately and instantly every deviation.

Mr. Sperry emphasizes the importance of a guiding element that is instantly and minutely responsive, to be employed as the base line so that the slightest departure from the course may be utilized to apply the correction in order to make automatic steering practicable. He also refers to the futility of trying to use a magnetic compass for this function and cites the proposed use of highly complicated gyroscopic elements as the other extreme.

This leaves an opening for the introduction of a proposed means for automatic steering, known as the wake system, in that the base line is the before-mentioned line towed in the wake of the ship. In the case of a small motor boat, the stiffness of the line against deflection by yawing is sufficient when properly connected to produce a prompt and proportion-

ate counter helm. This counter helm is quick and strong for a sharp swing, but gentle and slow for an easy swing, and, in each case, dies out to zero as the boat returns to its course. Furthermore, and of utmost importance, is the fact that the base line always lies in the course made good, and the boat's axis can and does automatically take up various angles with this line in order that the course made good may not be disturbed by the variable action of wind, sea or propeller throw.

For the automatic steering of ships, it will be necessary to relay the side resistance of the line through an electric motor to the actuating member of the power steering gear. This has been worked out in a practical manner but has not yet been tested. The plan shows the line passing between two pilot switches which are wired to a reversing contactor controller. A motor geared to a slow rectilinear motion is magnetically attached to the tilting box if hydraulic, or the throttle valve if steam steering gear is used.

A follow-up rod from the rudder stock moves the inboard end of the wire to counteract excess helm and to make the automatic adjustment against drift.

When the ship's axis has been placed on the compass course, necessary to make good the desired course as indicated by the draft angle registered by the towed line, the quartermaster closses the switch which puts the motor in charge of the steering through its magnetic connection. Thereafter, any deviation of progress from the base line sets up a proportionate countering helm. The axis of the ship is not locked to any fixed course as is the case with the gyro system. After a greater or less period, the compass will show an accumulated error and the quartermaster will open the switch, steer by hand to correct the course, then close the switch again. A necessary change of course would be carried out in the same manner except that it will be necessary to steer by hand for at least four minutes in order that the drag may have time to come into the new wake.

The motor, while in change of steering, will cause the pilot wheel to rotate through the reverse action of the telemotor, thus indicating that the automatic system is working and showing the frequency and extent of the helm movements.

It is to be noted that the gyro system, by means of a compass, holds the ship's axis to some course that is manually adjusted by estimation from time to time, so as to make good the desired course; while the wake system works solely to the course being made good as indicated by the wake, and allows the ship's axis to take automatically whatever headings are necessary to prevent deviations.

I have a few slides that I would like to show.

Plate 8 is an actual record made on the motor ship Missourian, the degrees of variation from the course at this side of the slide, the effect on the projected beam of the ship on that side (indicating), adding 8 feet to the projected beam for every degree of yaw.

Plate 9 is a scale drawing of the prism which is displaced in the sea by a ship yawing 2.5 degrees in each direction. This is taken from actual records. This represents a time of one minute, or 2.5 ship length. A speed line can be drawn in which will show a corresponding dip with each one of these yaws.

Plate 10 shows the total angle of rudder used by various quartermasters during one day, together with their maximum angle used.

Plate 11 shows the application of wake steering to a small boat, and shows the line fastened to the deck and passed through a clamp on the tiller. After adjusting the boat to the desired course, the clamp is closed down on the string. A shadow cast by a vertical member here on a scale shows that the boat is holding to its course within one-half degree, and shows the variations under variable wind conditions.

Plate 12 shows a diagrammatic application to an actual steering gear. These switches operate the motor, either forward or reverse, which, in its turn, operates the gear.

THE PRESIDENT:—Is there any other member who desires to say something on this paper?

MR. WILLIAM W. SMITH, *Member:*—Mr. Rogers stated that the resistance in a particular case would be reduced about 16 per cent by automatic steering.

MR. ROGERS:—I beg to state that I did not make any such statement as that—

MR. SMITH:—I beg your pardon.

THE PRESIDENT:—Didn't you say that the power was increased 16 per cent?

MR. ROGERS:—I said that Mr. Sperry's paper stated that that saving had been made.

THE PRESIDENT:—I thought you were one of Mr. Sperry's men when you started out, and it was not until you had gotten quite away along that I found you had a rival system.

MR. ROGERS:—Mr. Sperry gave the specific resistance of the rudder as 9,300 pounds, which figure represents about 16 per cent of the available energy of the power plant.

MR. SMITH:—I ask if the author or Mr. Rogers, either of them, could give us an estimate of about how much resistance could be saved under average seagoing conditions between magnetic steering and automatic steering. If they could give us such an estimate, it certainly will be of much value.

COMMANDER H. S. HOWARD (C.C.), U. S. Navy, *Member:*—Mr. Sperry's paper is of particular interest to those of us in the Bureau of Construction and Repair, where we have followed with care all proposed schemes for automatic steering and all developments along such lines. I feel that Mr. Sperry is to be congratulated upon the excellent results which he has obtained.

There is one point upon which further information would be appreciated. In any system such as this, in which the effort to return a ship to its course depends upon absolute deviation from that course, it would seem that the steering gear would keep the rudder over until the ship had regained the intended course. Her head would then, due to inertia, keep swinging beyond this course, which at once would cause the steering gear to operate to move the rudder to the other side. In other words, with this type of automatic steering, it would seem that the ship would steer a sinuous course, the steering gear constantly hunting to keep the ship on the proper mean course.

Although the preceding seems to be the natural deduction from what is understood of the arrangement of automatic steering gear described, the curves of performance do not show such a result.

I should like to ask whether any means for correcting such a hunting action of the steering gear was employed or whether any such means is considered necessary.

MR. MILLS:—In connection with Mr. Rogers' statement I would like to point out that when he goes to sea with his apparatus he will find out a lot of things he does not know now.

We have discovered, since we have gone to sea, that every ship acts differently. We found very quickly that it was entirely possible to avoid any hunting in keeping the ship on its course, and it is just as easy to keep the ship on its course by proper manipulation of the automatic machinery, as can well be imagined. The weather does not usually change materially in a minute or an hour, and if a man can, by making suitable adjustments, take care of his ship every hour, or every two or three hours even, it is not a particular hardship for him to do it, and this device makes it possible to keep the ship on such a true course that it is well worthy of doing it.

I will say, in answer to Commander Howard, that the S. S. Munargo, over a period of twenty-four hours, in the same sea area and the same kind of weather, actually made, by automatic steering, a half knot more speed, at three revolutions of the engine less, which the chief engineer of the ship solely attributed to the automatic steering.

MR. ROGERS:—What percentage is that?

MR. MILLS:—She is a 16-knot boat. I do not know how close that comes to Mr. Sperry's estimate, but it shows a very marked saving.

In connection with hunting, in answer to Commander Howard's query, the ship does not hunt. She has large inertia and, owing to the quick rudder control, never swings far or builds up large forces. The rudder control with the automatic steering is so much faster that, if you happen to be in the steering engine house, you can tell immediately, when the ship changes from manual to automatic, by the reduction of rudder angle, and the more frequent application of small angular change. Still, it does not hunt, as you might imagine, through these small angles. Often for a period of two or three minutes, the rudder will remain stationary, because there are no inertia effects built up in the ship.

THE PRESIDENT:—The next business on the program is the presentation of the paper entitled "Details of Naval Design from Jutland," by Commander Herbert S. Howard, C. C., U. S. Navy, Member.

Commander Howard presented the paper. During its presentation Rear Admiral David W. Taylor, C. C., U. S. Navy, Honorary Vice-President, occupied the chair.

DETAILS OF NAVAL DESIGN FROM JUTLAND.

By Commander Herbert S. Howard (C. C.), U. S. N., Member.

[Read at the thirtieth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 8 and 9, 1922.]

In the introduction to a book entitled "A Naval Lieutenant, 1914-1918," written by an officer in the British Navy under the name of Étienne, there appears this paragraph in which he gives his reason for writing the book:

"Much of our knowledge of the details of the great naval wars of the Napoleonic days has come from letters, diaries, and personal accounts published at the time in the naval chronicles, and the historian of the future will seek for similar sources of information."

This quotation very well expresses the fact that more information on the subject of a particular battle is often obtained through the personal accounts and diaries of those who were engaged directly in the fighting than from rather dry official reports and records made up with great care after the battle was over. The author in his book had particularly in mind, it is believed, the usually accepted type of historian, but the statement made holds equally true for the researches of what might be termed a technical historian.

The many reports and discussions that have been published on the Battle of Jutland almost invariably have to do either with controversial points of strategy, movements of fleets and so forth, or major questions of design, particularly those comparative between British and German ships such as protection of vitals, turret magazine protection and so on.

These questions have been treated and retreated: strategy by the ablest naval strategists in all countries possessing or interested in navies, and major design questions by the leading naval constructors and naval specialists in England and Germany.

There is a field, however, in which, as far as is known, no naval designer or constructor of naval vessels has as yet ventured, and in which it seems such a one should venture. That field comprises the performance of the different detail features of design of the naval ships in the battle.

Personal accounts have been written, one which it will be remembered was referred to at the beginning of the paper, by those who went through the battle. In these accounts we read, not of the movements of the fleets and the large questions of strategy on hand that day, but of the particular events which took place on board the ship on which the writer was at the time. Most naturally he was interested first and foremost in the things that affected his own ship, and if this ship happened to be one which suffered a good deal of damage under fire, we learn how the various details of design stood up to their work.

The published personal accounts of the battle are none too many, but they are of great value not only to the true historian, but to the technical naval designer as well, and, it may be added, most thrilling and interesting reading. In this paper an attempt has been made to analyze these accounts as far as concerns the principal minor features of design of naval vessels. As may be imagined, the accounts available from those on British ships are much

more numerous than from those on German ships, so that much information is lacking as to the latter. Of the books consulted two should be mentioned in particular: "The Fighting at Jutland" and "A Naval Lieutenant, 1914-1918," and to the compilers of one and the author of the other I wish to express my appreciation and thanks.

The following table gives a list of the ships sunk in the battle, or as a result of it:

British.		*German.*	
Queen Mary	Battle cruiser.	Lutzow	Battle cruiser.
Indefatigable	Battle cruiser.	Pommern	Battleship.
Invincible	Battle cruiser.	Weisbaden	Light cruiser.
Defence	Armored cruiser.	Elbing	Light cruiser.
Warrior	Armored cruiser.	Rostock	Light cruiser.
Black Prince	Armored cruiser.	Frauenlob	Light cruiser.
Tipperary	Destroyer.	V-4	Destroyer.
Turbulent	Destroyer.	V-27	Destroyer.
Fortune	Destroyer.	V-29	Destroyer.
Ardent	Destroyer.	S-35	Destroyer.
Shark	Destroyer.	V-48	Destroyer.
Sparrow Hawk	Destroyer.		
Nestor	Destroyer.		
Nomad	Destroyer.		

Of the ships listed, the Queen Mary, Indefatigable, Invincible, Defence, Black Prince, Weisbaden and Pommern were sunk as a result of complete explosion resulting from a salvo reaching a vital spot, or from a torpedo. The Elbing and also the Turbulent were rammed and sunk by German battleships.

These losses are generally eliminated then as involving major questions of design. Moreover, the destruction of those blown up was so sudden that it may be said no record of the performance of the detail features of design remains. We have left, then, of these total losses, on the British side one armored cruiser and seven destroyers, and on the German one battle cruiser, three light cruisers and five destroyers. Moreover, there were, on both sides, other ships which suffered very severely but which lasted through the battle, and from them excellent accounts have come. Of these might be mentioned in particular the Warspite, Southampton and Derfflinger.

Fire, it is believed, might, among our list of details of design, be taken as the principal source of danger to fighting ships and those aboard them. It brings in questions of inflammability of materials, fire systems, pipe lines and sometimes unexpected matters in its wake. Particularly it always brings with it the ever-present menace of magazine explosion.

The examination of our records shows many accounts of fires. The armored cruisers Black Prince and Warrior of the British fleet and the battle cruiser Lutzow of the German fleet were all heavily on fire until the first-named blew up and the two latter were abandoned; on the Warspite, which came under the concentrated fire of the German fleet while her steering gear was out of commission, many fires raged; the light cruisers Dublin, Southampton and Chester all had severe fires as had the destroyers Tipperary, Spitfire, Defender, Onslow and Acasta. The Colossus, Malaya, and possibly other battleships of the Grand Fleet had minor fires, while the Lion and Derfflinger each had bad turret fires. There may

have been, and probably were, many more fires, particularly on those ships which were blown up outright, but the above gives quite a complete list and one which contains different types of ships, so that deductions made therefrom should be sound.

It will be found that, of these fires, many were entirely cordite fires, shells exploding in the vicinity of ammunition brought up and held ready to serve the secondary battery of large ships or the main battery of light cruisers and destroyers. In the Warspite, Colossus and Malaya fires of this type occurred, and in two of the three cases, at least, the fire ran right down the secondary battery on the side hit. In the Tiger a cordite fire was caused by a shell piercing the side armor and exploding inboard in an ammunition passage. Of the principal fires on the Southampton and Chester, both were cordite. In Q turret of the Lion and the two after turrets of the Derfflinger powder fires resulted from shell explosions, and the turrets and chambers below were completely burnt out to the magazine doors.

On destroyers in general it would appear that, as might have been expected, one or two direct hits by large shells were enough to put the ship entirely or almost entirely out of commission. The same result followed from a few salvos from a light cruiser. Under these conditions fires broke out at once. The next natural thought which results is that on oil-burning destroyers severe oil fires should have occurred. This, however, does not seem to have been the case. Of the destroyers from which we have accounts, the Acasta, Onslow, Nestor, Nicator, Defender and Petard were all oil burning. All six suffered very heavily under attack by the enemy, and on the Acasta, Onslow, Defender and Petard there were severe fires. Yet of these four, on two only were there apparently oil fires, and in both cases the oil fires were overcome quickly and effectually. In the Petard an oil-fuel pipe was severed and the oil was set afire, but the oil was shut off and the fire stopped. The Defender received a 12-inch shell sideways, from a ricochet, in the forward fire room and a fierce oil fire was started. This fire again was put out by hard and brave work.

The deduction from this is that fuel oil does not seem the menace to light ships that it has at times been considered. However, this question brings up a point well worth introducing. From an account of the battle in the book "Kiel and Jutland" by Von Hase, gunnery officer of the Derfflinger, the inference is that every oil-burning British destroyer which was heavily hit burst into flames and the burning oil spread all over the ship. Such undoubtedly was the appearance, as most of his observations of this kind were made at night, and all accounts show how terrible and awe inspiring was the sight of a ship on fire at night. However, the stories of those who were on the British destroyers that were severely damaged that night do not bear out the German record. This shows how careful we must be in accepting reports made by any observer as to what happened on another ship, and in drawing deductions therefrom, and contrariwise how valuable are reports from those on board ship as to the events on that particular ship.

When we consider fires in general, and eliminating cordite and oil fires, just discussed, the most serious seem to have occurred on the Warrior and Black Prince on the British side and the Lutzow on the German. Of the Black Prince we have no record except that she seemed completely on fire as she steamed along at high speed just before blowing up, but from the Warrior there are survivors whose records show that vessel to have been all on fire below decks from about amidships aft. However, both these ships were old armored cruisers, practically obsolete vessels for this kind of work, and both were under the concentrated fire of the High Seas Fleet for some time. The wonder is that they lasted as long as they

did. Of the Lutzow, all we know is that she was heavily on fire and continued so until she was abandoned.

Of the other ships under consideration, the accounts show that each shell explosion, particularly below decks, left fires in its trail. For a time, probably due to the enormously high temperatures generated, everything in the vicinity seemed to burn. Nevertheless, except in very serious cases, it seemed to be possible to cope with the fires most effectively in rather short order. Also, where some materials burned which had not been looked on as inflammable, other materials which had been considered as possible sources of danger, as, in particular, the wood decks, gave no trouble in this respect.

In dealing with these fires, the most serious difficulty was apparently the fact that in many cases the shell explosion which caused the fire completely wrecked the fire main and hoses in the vicinity. Besides putting the local fire-fighting equipment out of commission, water from the broken fire mains poured out on the decks and down below into engine rooms and other spaces where holes in decks or hatches existed. This possible cutting of fire mains seems a subject worthy of very particular study, and as a suggestion it would seem that shut-off valves with distant control gear, together with long emergency lengths of hose kept below protection, are necessary where fire-main risers pierce armor decks.

Another point that was brought up in speaking of these fires was the danger to the fire parties from the sharp edges of torn decks and bulkheads and also from molten lead dropping from lead-sheathed electric cables. To meet the former point heavy boots and gloves should be supplied to fire parties, while to meet the menace of molten lead they might also be equipped with firemen's helmets and leather jackets, for it seems impossible, or at least impracticable, to consider not running lead-sheathed cables overhead above the armor decks.

Summing up the subject of fires, it would seem that, if anything, the fire menace proved to be in general less serious than had been expected. Many and most severe cordite and other powder fires did occur and showed the need for greater care of ready service ammunition and more subdivision of the secondary guns. On the other hand, oil fuel did not seem a particularly potent source of danger. However, to meet conditions which will undoubtedly exist, fire-fighting equipment should be kept up to the top notch. Design, moreover, should be such that, even with fire mains above the armor deck damaged, it will still be possible to obtain a supply of water for fire-fighting purposes.

Outside of the main engines and boilers of a naval vessel, probably the most important item of her machinery is the steering gear. This, as anyone knows who has had to do with specifications, tests, or design of a steering gear, is a piece of apparatus which must meet the most severe conditions. Its work varies almost instantaneously from no load at all to heavy overload; the shocks of the sea must be met, and above all it must be ready for work whenever it is wanted, and all the time.

In every naval vessel, at least, we specify very severe tests for the steering gear; hard-over to hard-over and back again in a few seconds with the vessel at its highest speed, going ahead, backing and swinging. It is to be feared, though, that we are all prone to heave rather a sigh of relief when the tests are over and say to ourselves that that is over, and the gear probably will not get another test like it in the course of the life of the ship. Now in that feeling and in that point of view this battle of Jutland shows us to be wrong, and to me this question of steering gear and how it should perform is one of the most important lessons gained from this study.

Almost throughout the whole battle, certainly during the day fighting and, in particular, when the British battle cruisers and the 5th Battle Squadron were engaging the German fleet, every ship was going at top speed. In fact, speeds that had never been reached on trial were considerably exceeded, as, for example, the light cruiser Chester worked up to 28 knots when her best speed on trial had been 26½ knots. In addition to this high speed, the ships did a great deal of maneuvering. This came about through ordinary changes in course for tactical reasons, through very sudden changes in course, to avoid either an approaching torpedo or the salvos of a pursuing ship, and in some cases to avoid running down another ship when congestion occurred as during the deployment of the Grand Fleet.

It is easy to understand at once what enormously heavy duty these conditions brought upon the steering gear and why breakdowns resulted. The best known of the breakdowns, and the most serious, occurred in the Warspite which, at the time of the 5th Battle Squadron's joining the Grand Fleet, jammed her helm at 15° port and as a consequence made two complete circles toward the enemy, meanwhile being under the fire of almost the whole German fleet. The steering engine in use was finally disconnected and the other engine connected up, but again the ship could not be steered, and it was finally found that the reserve engine had been thrown in with the rudder at 15° port instead of amidships.

Other cases of jammed steering gear occurred on the Invincible and Chester. The former, in joining in the battle with her squadron, was obliged to dodge torpedoes, and the helm suddenly jammed at hard-over so that the ship made a complete circle, but fortunately without ill effect. The Chester, a light cruiser, came under the fire of a whole squadron of German light cruisers, and in escaping from their salvos was obliged to zigzag at high speed. While so doing her helm jammed hard aport, but luckily for the ship the gear was cleared almost at once.

Of these steering-gear jams the only one of which we have the probable details is in the case of the Warspite. In that ship both steering engines were secured on a vertical bulkhead in the engine room, and, as far as could be told, the bulkhead was strained by the bursting of a shell in the vicinity. The result was to throw the engine out of line and cause it to labor and run hot. When the order was then given suddenly to put the helm over, the engine could not handle the sudden load and the jam followed. Of the mishaps on the Invincible and Chester we have no details, but it may be inferred that they were due entirely to the excessive speed and sudden changes of course.

These accidents bring forward the great importance of the steering gear and primarily the fact that trial and test conditions are not those of trial alone, but the very conditions which will be met with and quite possibly surpassed in battle. To avoid similar mishaps in the future the gear must first of all be so located as to be as free from the surrounding structure as possible, so that damage to that structure may not be communicated to the foundations of the gear. Also in the design there must be no weak points, while the operation must be as simple as possible to prevent mistakes in connecting up or disconnecting in the excitement of battle. Finally and most important, the trial condition tests must be accepted as the ordinary working condition of battle.

To speak of turrets may be approaching very closely to major points of design which it was not intended to touch. Nevertheless, the accounts of the battle bring up so many interesting points to do with damage to turrets, and particularly their great powers of resistance against attack and their ability to keep going in spite of damage, that they cannot be passed without mention at least.

Of the records consulted, these show direct hits causing damage on turrets of the Lion, Tiger, Malaya, and three turrets of the Derfflinger. Many other direct hits on both turrets and barbettes of various ships were received without either penetration or damage, but the hits of interest to examine are those where damage was received. Of the battle cruisers blown up, some at least may have received their death blows through penetration of turrets or barbettes and explosions within, but that we cannot say.

Of these particular cases mentioned, an 11 or 12-inch shell penetrated Q turret of the Lion and exploded inside. The immediate result was to put the turret out of action. A few moments afterward, however, a powder fire followed, ignited undoubtedly from smouldering material, which burned out the whole substructure down through the handling room. Practically the same thing happened in the two after turrets of the Derfflinger. Both were struck by 15-inch shells. In one case the turret itself was penetrated, and in the other the roof plate was pierced. In each case the shell exploded inside. In both the result was the same as in the case of the Lion, the flame from the explosion, or burning materials remaining in the turret, igniting powder brought up for loading, so that fires burned out the entire barbette spaces down through the handling rooms. In all three of these cases the fire and damage stopped at the magazine doors. The turrets and whole turret structures were completely gutted and the turret crews wiped out, but the magazine doors saved the ship from destruction.

The other cases of turrets on the Tiger, Malaya and forward turret of the Derfflinger, however, show the resisting power of the turrets themselves. In the Tiger a direct hit was received on the roof of Q turret. Penetration did not result, but the explosion smashed a hole in the turret roof so that pieces of armor were driven inside and a number of men killed. No vital material damage was done, however, and in spite of what appeared to be major damage the turret was got working again, the left gun as before and the right gun with hand loading. Almost the same thing happened with X turret of the Malaya, in which a direct hit so dished the roof that from outside it was quite possible to see the crew at their work inside, but no interruption to the fire of the turret resulted. On the Derfflinger the forward turret was jammed by a heavy hit directly on the water shed. The turret crew jumped out on deck and in a short time, with axes, crowbars, and other improvised tools, cleared the jam away so that the turret proceeded as before.

For many years armor gratings have been fitted in the openings of armor decks of warships, and for many years ballistic tests of these gratings have been carried out at various proving grounds to test the resisting power against major shell impact, or the impact of smaller shells representing fragments. While these tests have been of great importance, they have never represented the grating in its actual service condition. In proving ground tests, the grating is always held in some rigid framework, and it is practically impossible to reproduce the conditions which would exist between the grating and the deck which carries it.

Now, however, we find a real service test, and it is well worth our while to see what the results of this test show.

On the Warspite a 12-inch shell struck the armor grating over one boiler room, but did not penetrate and was deflected upwards. The gratings were bent, but none broken, and apparently did all the work intended. Subsequently it was found, besides this particular hit, two other heavy hits had been received direct on the gratings, but in each case the shell was deflected. These reports indicate most clearly that reliance may be placed upon well-designed armor gratings.

After the battle the splinter nets below the gratings were found full of fragments, which confirms the opinion held as to the necessity for some additional protection below those gratings which receive the direct impact.

Rather an extraordinary thing occurred on the Derfflinger. In the middle of the battle the main central or plotting room suddenly filled with gas and had to be abandoned. Grave fears were felt for the safety of the ship, since it seemed impossible that, without great general damage, gas should have penetrated to this carefully isolated compartment. Somewhat later, however, the exhaust fans were started by men entering with gas masks, and the compartment was at once cleared of gas. It was then found that the gas from the powder fires in the after turrets, and probably also from the ship's own guns, and from shells exploding aboard, had passed down the voice tubes to the central and temporarily put the station out of commission.

Large volumes of gas from similar causes also filled the Derfflinger's engine rooms so that men were overcome and died, and for a long time the engine-room force had to work in gas masks.

We may feel sure that no poison-gas shells were used in this battle, and the flooding of the central and engine rooms with gas resulted only from powder fires and smoke from other sources. However, the result was the abandonment of one station and the complete use of gas masks and loss of men in the other. There was clearly shown here the danger from gas penetration through voice tubes, and in fact through any form of communication between compartments through which gases may pass.

Torpedo nets had been used both by English and Germans for many years before this battle, the former having, it is believed, been the first of all navies to introduce their use. As far as is known, the British removed them from their ships before Jutland; at least photographs made on that day do not show them, and there is no mention of them in the accounts of the battle. The Germans, however, went into battle with the nets on board stowed brailed up against the side in sea position. Before the day and night were over they regretted many times, it is believed, that they had not left them behind.

The Derfflinger, as has been referred to before, had been handled very roughly during the day battle between the fast squadrons of the two fleets. Later that evening, shortly after the two forces had lost touch, word was suddenly received on the bridge that the ship must stop. The after-torpedo net had been shot away and was hanging in such a position over the port propeller that it might foul at any minute. So the ship was stopped and she drifted about for a time long enough, and it must have been considerable, to haul the net on board and secure it so that it could not get away again. Had this happened an hour or so earlier, the Derfflinger would have lain stopped under the guns of the British fleet, and it is not hard to imagine that the Germans under those conditions would have taken one battle cruiser less back to port.

That torpedo-net troubles were not confined to the Derfflinger is confirmed by Admiral Scheer himself, who states that after the battle the nets on most of the ships were so damaged that it was impossible to remove them. In many cases they hung down in festoons, so that it was a wonder that propellers were not entangled.

It has been realized for some time that nets could be of service only to ships at anchor or at the slowest speed. Now we have it most clearly shown that they may become a grave menace to ships in battle. It would seem, then, that the case against the torpedo nets is complete.

Our analysis of the personal accounts and reports of the battle of Jutland has given data on the question of fires and fire fighting, steering gears and their performance, turrets, the resistance of armor gratings and splinter protection, gas penetration of interior spaces, and the performance of torpedo nets. In every case the evidence has come from the men who were right on the spot. They were the men who have to work with the materials which we ship designers and shipbuilders give them, and in this case it was no idle opinion expressed as to whether such and such a piece of apparatus could do the work under probable battle conditions. Here the battle existed, and the apparatus either worked or it did not work, and the record is plain to read.

For these reasons it seems that the conclusions drawn above are of great value to all directly concerned in, or interested in, the design and building of naval vessels. The subjects considered are not many, but only those were treated on which good evidence exists and from which sound conclusions could be drawn. It may be that further search, particularly of the German libraries, will disclose other personal accounts of this most interesting battle. If so, our knowledge of the performance of the details of design under battle conditions can be extended just so much further. If this be done, and the lessons learned put to practical use, I feel strongly that our warships of the future should be just so much the better able to meet the tasks for which we build them, but which we hope will never come.

DISCUSSION.

THE CHAIRMAN:—Gentlemen, you have heard this paper No. 2, entitled "Details of Naval Design from Jutland," by Commander Howard. The paper is now open for discussion.

PROFESSOR W. HOVGAARD, *Member* (Communicated):—In peace time designers of warships are guided by theory and experiments and by the experiences obtained in ordinary service, in maneuvers, target practice and sometimes through accidents, but to a development on this basis there attach many uncertainties which can only be dispelled by the experiences of war. Seen in this aspect, naval actions may be regarded as full scale experiments and, as such, form the only reliable source of information on many questions of design. It is therefore of the greatest importance to analyse naval warfare from this point of view. The behavior of ships under the stress of war service, their suitability for the particular duty to which they are assigned, the damage which they suffer in action and their behavior under various forms of attack—all these points should be carefully studied and an attempt made to draw conclusions which may be useful in the design of new ships. Such an analysis is by no means an easy matter. The experiences of battle are often misleading and may even at times appear to be contradictory. This is explained by the fact that the complex conditions which surround naval actions are rarely similar. The result depends not only on the material but also on the human element and on the physical conditions of weather and light. These factors intermingle and often obscure one another.

Commander Howard has successfully overcome these difficulties. He has analysed the damage suffered by the various classes of warships in the battle of Jutland and in the paper deals in particular with such points as have not before been fully discussed. His analysis is carefully carried out in a scientific and cautious manner. He bases his generalizations on the facts from a great number of cases, and he avoids all hasty and sweeping conclusions. His paper, therefore, cannot fail to be of great value to designers.

The emphasis which the author lays on the importance of a robust and reliable steering gear, as well as on its effective protection, is most timely. The requirements to quick maneuvering at high speed, for instance in dodging torpedoes, are higher than ever. It appears that no other mechanical appliance in the ship, excepting the machinery of propulsion, is equal in importance to the steering gear.

Another point emphasized in this paper is the danger of fire due to the ignition of powder charges. This is a point to which designers should give the most careful study. While no arrangement can be devised which will completely eliminate this danger, much can be done to reduce it to a minimum. It should be borne in mind, however, that in this respect a careful organization of the service of ammunition handling is equally important. Cases are on record from the war where the enthusiasm of the men led them to hand up the ammunition to the secondary battery much faster than it could be used, resulting in a dangerous accumulation of powder at the guns.

I take this opportunity to draw the attention to certain points not referred to in the paper, but on which I believe it is safe to draw conclusions.

1. *Towing Appliances.*—During the war numerous cases occurred where towing of disabled warships was necessary, and in some cases the life of the ships depended on the success of this operation. Often towing took place under difficult weather conditions, sometimes under the fire of the enemy. This shows the great importance of equipping warships of all classes with handy and efficient towing appliances, as well as the need of a thorough training of the personnel in this kind of work. Such training should be carried out under all kinds of weather conditions, day and night, so as to make the personnel familiar with the appliances and with the handling of the ships under such conditions. This would soon lead to improvements in the equipment. Especially when one heavy ship tows another heavy ship, the inertia strains are apt to become excessive and in such cases we hear almost invariably of the breaking of towlines (Audacious, Olympic, Moltke, Oldenburg).

2. *Leak Stopping.*—The importance of being able to stop leaks promptly and effectively was hardly realized sufficiently prior to the war, but was brought out on many occasions (Warspite). The means and appliances most suitable for this purpose should be provided and the service pertaining thereto carefully organized.

3. *Righting Ship.*—Most of the warships that went down during the war capsized before they sank. To prevent or to delay the process of capsizing and, in general, to right a ship quickly whenever she takes a list, is evidently of the greatest importance. Hence, powerful means for righting the ship should be installed, at least in all capital ships, and the personnel should be trained in its use.

4. *Location of Feed-Water Tanks.*—The serious consequences of salt water entering the feed tanks were evidenced during the war, the motive power of ships being almost completely crippled on several occasions due to this cause (Arethusa, Lion, Onslow, Moltke). Feed-water tanks should, therefore, be so placed as to give them the best possible protection. In fact, those tanks should be regarded as belonging to the vitals of a ship.

Rear Admiral Albert P. Niblack, U. S. Navy, *Vice-President:*—I think that in previous battles, like Tsushima, and even in our Spanish War, we learned the danger from fire to paint work on board ship, but the fires which this paper discusses are extremely interesting, as I had not seen the facts brought out in such a distinct way as is done by the author. The paper has particular value for this and other reasons.

While modern shells are fitted with poison gases, the gases resulting from the explosion of any shell are in effect poisonous, whether intended so or not, and one of the valuable lessons we learned from the Battle of Tsushima was that the gases from shell explosion were taken up by the ventilating systems and distributed to where they could do the most harm. We must redesign our ventilating systems in some cases, but at any rate gas masks are a necessary part of ship equipment.

As to the other interesting question of torpedo nets, I want to throw a little sidelight on it by saying that we have never had torpedo nets in our navy, and we have been unique in that respect. I was in Germany as naval attaché twice, and was there just before the war. I remember in 1912 a discussion on the question of torpedo nets for the German navy, and I was approached on the question several times as to why we had omitted them in this country. The nets, when put around a ship, practically limit the speed of the ship to 10 knots. One reason given by a German authority for having them was psychological. It was argued that as a ship would be practically invulnerable if it were protected by nets, the crew would sleep better. That was the very opposite of our reasoning. We argued if you did not have nets you would be very much more alert, which in itself is a good argument.

There is one little phase of this question to which I will call attention, and that is, in a battle, in the falling of salvos, columns of water which are raised become positive sources of embarrassment to the ship, whether the shall hits or not, because of the great quantity of water going on board from a shot striking near the ship. It has been known to disarrange all the gun sights by deluging the optical instruments with water. I have not seen any data in this connection, in the Battle of Jutland, in regard to the extent to which the water from salvos got on board, and interfered with proper control, but this question of water coming on board was commented on in the battle of the Falkland Islands. The British ships in chasing the German ships suffered very seriously from water coming on board from shots, not actually striking the ship but striking near the ship. Many similar questions might be of further interest in discussion of the Battle of Jutland, but it will be some time before we get all of the details of that battle.

Commander Emory Land (C. C.), U. S. Navy, *Member:*—Commander Howard deserves the thanks of the Society for attacking a job in which so much digging into details is involved. He has produced some excellent results, and my only regret is that his paper is so brief; it is a sort of *multum in parvo* and we need more light.

It appears to me that he might have included some comments on the question of shell hoists and their installation, which is a matter of major importance, although not necessarily a matter of major design. It will probably be a long time before there will be another Battle of Jutland, and I suggest that it would be a good idea for the council to ask Commander Howard to prepare a paper next year, in which the lessons that might be drawn from this battle could be brought out in further detail. This paper might well cover such subjects as water-tight doors, flooding systems, drainage systems, life-saving apparatus, signalling, communication systems such as the use of telephones and voice pipes. If records of these instal-

lations are available, a paper covering them would form a valuable reference for all of us interested in design and construction work. Probably, by next year, additional German records will be available to supplement the present paper, which is of intense interest to all of us.

We have to be cautious in installing what some of us call "gadgets" to take care of remote contingencies. It is hardly worth while to care for such remote contingencies in the design and construction of warships. Every man who goes to sea has to take a chance, and from a reasonable point of view it is impracticable to attempt to cover what I choose to call remote contingencies.

I am particularly interested in the steering-gear comments of Commander Howard, who has been intimately connected with steering-gear installations and specifications since he entered the Navy, and who is in an excellent position to give us some very valuable information on this subject. He has probably written more submarine steering-gear specifications than anyone else in the service. The importance of having very rigid tests for steering gears cannot be overestimated. Severe service tests are not only essential for emergency conditions existing in time of battle but also essential for many peace-time conditions which occur in maneuvering, docking, and where collision is to be avoided. One of the ablest British architects of today has stated that the steering gear and propellers form the Achilles' heel of modern capital ships.

I believe, if Commander Howard had touched on the submarine casualties in the war, he could have given us many examples of submarines being lost by virtue of their diving gear, or steering gear, or both, having been damaged. As a matter of fact, damage to these installations was the primary cause of the loss of a great many German submarines.

After we get these installations on board ship, which is the province of the naval architect and shipbuilder, it is the province of the operator to use them. One is useless without the other, and I should like to point a small moral to the effect that, if you do not use the things aboard ship in the way they are intended,they become useless. We have made a good many efforts from time to time to fight fire aboard ship, and put in rather complicated systems; in one or two instances, one or two people aboard ship have used them. In other instances they have not been operated. We can take a number of leaves out of German practice with regard to the installation of things of this kind, not only with respect to fire fighting apparatus, but, as Professor Hovgaard brought out, in counteracting flooding. Construction and operation must go hand in hand, otherwise we get a lot of useless weight aboard ship which the personnel does not use in time of emergency. Sometimes this apparatus is not used because the men do not know how to use it, and in other cases it is not used because they will not use it. A watertight door which is open when the ship is damaged does not help much. We should take the experiences of the operators and incorporate these in our designs.

Rear Admiral David W. Taylor (C. C.), U. S. Navy, *Honorary Vice-President:*— This is a paper which is of great value to the Transactions of the Society because it represents research which has established actual facts, and when we have facts established a naval architect can proceed with much greater confidence to his problems than when he works with opinions formed by arguments alone.

Commander Howard showed, broadly speaking, that the vessels of war in the Battle of Jutland representing both sides functioned as designed. It was remarkable how well the offense overcame the defense, and, on the other hand, how well the defense stood off the offense. The defensive and offensive apparatus functioned more or less as designed.

I was struck, in hearing this valuable paper, by the fact that so many of the matters touched on are matters which have been questions of discussion and controversy in all navies for a great many years.

The question of fire is perhaps one of the most important. Some of us will recall that after the war between China and Japan in 1894 the question of fire became very acute. Battleships in those days had more joiner work than the ordinary passenger vessels in these days, and when they got afire they burned like tinder. Whereupon we made an endeavor to remove all possible woodwork from our ships, and inside of two or three years we had practically no joiner work, and no wooden decks except the weather deck, and that has been our practice ever since. We thought we were fairly safe against fire.

Then the war between Russia and Japan came along, and we had the battle of Tsushima Straits, and we had dreadful accounts of what happened to the Russian ships from fire. We heard from the Russian side that the ships got afire on the outside, because of the paint taking fire. That was a very disquieting statement, but fortunately it was not true. We did our best, those of us responsible for building the sh ps, in the endeavor to set paint on metal on fire. We could not do it with a blow torch. We exploded a number of shells in heavily painted steel compartments and they refused to catch fire. When you consider that the major portion of paint is already an oxide, a product of combustion, and the paint itself is a thin film on a metal surface which absolutely prevents combustion until the steel has been heated red hot, it does not seem reasonable to believe that the paint should catch fire.

Nevertheless, during the last war, the question of paint catching fire was very acutely considered. We had information that one of the combatants had scraped all paint above the water line off his warships. I remember that one very valuable member of the General Board was exercised about it, and he recommended that, in the case of our ships, all of the paint above the water line be removed. About that time he went to sea in command of a ship, and some wicked people in the department recommended that he be allowed to remove all the paint above the water line from his own ship, which ended that idea.

While there is no question that at the Battle of Jutland and in other battles there was a great deal of fire, I think you will find it was largely a case of ammunition fires.

I remember distinctly reading a letter from one of the English officers in one of the battles in which he remarked casually that at a certain stage they had had a cordite fire. He left his station to help put it out and then returned after it was out. The fact that there were cordite fires was brought out by Commander Howard.

I think one of the examples reported by Commander Howard was very remarkable. In more than one case shells penetrated a turret and killed every one in the turret, but did not explode the magazine. It is possible, of course, that the English vessels which blew up were blown up from that cause; in fact, this seems one of the most probable causes. I recall about 1893, when we were straining every nerve for rapid target practice, we had one or two similar occurrences where the turret burned out but not a single magazine exploded. We thought we were exceedingly lucky then, and it looks as if someone was exceedingly lucky in the Battle of Jutland.

The question of gas brought out by Commander Howard is very interesting. We heard about the time we went into the war that gas shells were going to be used at sea. As a matter of fact, they were not used, but we were very much interested, and we set to work and made a large number of gas masks, the best we could get out, so that we were very soon fitted out on our ships with gas masks.

As Admiral Niblack pointed out, the shell that is exploded produces a lot of poisonous gas. The worst gas that is produced by these shells is carbon monoxide, and at no time during the war, so far as I can discover, was any gas mask designed that would absorb carbon monoxide. Since then the work has advanced, and our gas masks are fitted to absorb carbon monoxide, which is an exceedingly deadly gas. Carbon monoxide is odorless and has very little apparent effect until it kills. Fortunately, it is light and soon rises and disappears. In the case of the gas from the powder fires, the damage was done mostly by smoke.

There is another matter—the question of nets. Admiral Niblack is correct in saying we have not had them, but I do not think he was in Washington at the time a large number of commanders demanded that we should have them. That question seasawed back and forth for a number of years. We never actually fitted them, but we had some of them ready to fit. The Oklahoma, completed in 1917 or 1918, has somewhere a complete outfit of double nets, a new invention which gave promise of keeping the torpedoes out, but these were not put into any practical use.

I am glad that the Battle of Jutland settled the question of nets. They are one of the most difficult things imaginable to fit, and the modern warship has plenty of things useful in war that are difficult to fit without being loaded down with fittings of demonstrated uselessness in war.

THE PRESIDENT:—We will now give Commander Howard an opportunity to close the discussion.

COMMANDER HOWARD:—The remarks which have been made upon this paper have been such as to extend its field and enhance its value very considerably. In the course of these remarks a few points have been raised upon which it may be of general interest to give somewhat further comment.

Professor Hovgaard brought up three matters untouched upon—towing, leak stopping, and righting ship. All three are of great importance undoubtedly, but the last in my opinion should come first. Righting ship, or, as more familiarly known in the Navy, "damaged stability control," is absolutely essential to prevent the capsizing of a ship due to severe damage, but, even without considering such extremes, it is of the greatest importance, for keeping a ship upright, that her guns may be used effectively. In these days of ranges so long as to have seemed utterly impossible a few years ago, a few degrees of list due to damage may put the enemy completely out of the range of our own guns while we are still under his effective fire. The Germans fully appreciated this point, and their methods of handling damaged stability and the training of the personnel connected with this work were far ahead of anything even conceived of in any other navy.

Admiral Niblack has stated that he has seen nowhere a report of gun sights or other instruments in the Battle of Jutland being interfered with by water from enemy shots coming aboard. Von Haase, in his account, speaks of this trouble being constant with his conning-tower periscopes throughout the battle. In fact, after a time the obscuring from water and smoke became so bad that cleaning could no longer be done with improvised rods and rags from inside, but he had to send a man on top of the tower to keep the glasses clean.

Commander Land has brought up, as he states, enough subjects for a new paper and, while the compliments paid in his remarks are greatly appreciated, comment upon these subjects will have to be reserved for consideration in the future.

THE PRESIDENT:—I am sure you will all want to extend thanks to Commander Howard for his paper and for the most interesting discussion which it has brought out.

We are going to change the order of reading the papers. The author of Paper No. 3 has requested that his paper come up this afternoon, so we will call for Paper No. 4, entitled "Stresses on Vessels of the Great Lakes Due to Waves of Varying Lengths and Heights," by Professor Herbert C. Sadler, Member of Council, and Professor Anders Lindblad, Member.

STRESSES ON VESSELS OF THE GREAT LAKES DUE TO WAVES OF VARYING LENGTHS AND HEIGHTS.

By Professor Herbert C. Sadler, Member of Council, and Professor A. Lindblad, Member.

[Read at the thirtieth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 8 and 9, 1922.]

When the Committee on Bulkheads and Freeboard met to consider the various problems upon which it was to report, the question of the possibility of including the vessels on the Great Lakes in the assignment of freeboard arose.

As little or no systematic investigation into the strength of this type of vessel had been made, it became necessary to make several strength calculations for the conditions met with in this region. As information of this character may prove of value in other fields, it was thought advisable to have the same in the permanent records of our society. The results of the principal parts of these investigations are submitted herewith.

In the first place, it became necessary to find out what lengths and heights of waves might be expected. Little or no data upon this subject existed, so a series of instructions was issued to captains of vessels in order that they might observe and report upon the waves encountered. Although all possible care was taken on the part of the observers, there was still a chance of error. On the whole, however, the data obtained were sufficiently reliable for the purpose in hand.

A few of the general conclusions are as follows:

1. As a rule, waves over 250 feet in length are rarely encountered. In one case, a report was made of waves in the neighborhood of 350 to 400 feet after a severe storm on Lake Superior, but although the height was not observed it was evidently not of the usual magnitude, judging from other comments on the behavior of the ship.

2. The heights of the waves appear to be somewhat larger in proportion to their lengths than the usual ratio of 1/20, and probably vary between this figure and 1/15. The actual heights did not appear to exceed 20 feet as a maximum.

The following waves were therefore used in the calculations: (*a*) 325 feet by 20 feet; (*b*) 300 feet by 20 feet; (*c*) 250 feet by 16.7 feet and two special cases, 325 feet by 15 feet and 350 feet by 20 feet, in order to obtain some intermediate data. As these waves are considerably shorter than the usual run of vessels on the Lakes today, it was necessary to perform two sets of calculations, one with the crest and one with the hollow at the bow.

Three types of vessels were chosen of the following dimensions: (*a*) 420 feet by 52 feet by 28 feet; (*b*) 504 feet by 56 feet by 30 feet; (*c*) 590 feet by 64 feet by 33 feet.

The wave profiles and corresponding positions of maximum bending moment are shown in Fig. 1, Plate 13, for all of the above cases; and the detailed shearing force and bending moment curves in the following Figs. 2 to 4, Plates 14 to 16.

As these vessels tend to sag when uniformly loaded, it is customary to put some additional cargo in the forward and after ends. This method of loading has been assumed as the proper one, although calculations were also made for uniform loading.

It will be noticed that both the magnitude and position of the maximum bending moment depend upon whether the crest or hollow is assumed at the bow, and also upon the wave dimensions. If the effect of varying heights of waves of the same length is desired, it was found that, for moderate changes, the bending moment varies as the square root of the height.

The results have been summarized in Figs. 5 and 6, Plates 17 and 18, in the form of bending moment factors.

STRESSES.

While the foregoing may be considered as general data with regard to bending moments on vessels, it may be of interest to add the special application in the determination of the strength of lake vessels.

If we take the form proposed by the British Committee on Freeboard as representing the strength, viz., $\frac{I}{y}$ = f. d. B., the following may be developed:

If s = stress, BM = bending moment, Δ = displacement, C = bending moment factor, and C_b = block coefficient:

$$\frac{I}{y} \times s = BM = \frac{\Delta \times L}{C},$$

$$\text{f. d. B.} \times s = \frac{\text{L. B. d.} \times C_b}{35} \times \frac{L}{C};$$

and if we assume $s = \sqrt[3]{L}$,

$$f = \frac{C_b}{35\,C} \times L^{5/3} \text{ for salt water}$$

$$= \frac{C_b}{36\,C} \times L^{5/3} \text{ for fresh water.}$$

The proposed values of f are shown on Fig. 7, Plate 19. It is obvious that if the waves on the Lakes do not exceed a certain definite length, the value of f should show a falling off after this length is reached. This is indicated on the curves, and it is interesting to note that numbers of the present vessels, especially the larger ones, show an excess of the above values; or, in other words, from a strength point of view, they could be loaded deeper than the present depth of water available allows.

In conclusion, and in light of the above investigations, it appears that the lake freighters of today are, for their service, as strong as, if not stronger than, similar ocean-going types, and the statement that these vessels are weaker is not borne out by theoretical investigation or practical operation.

DISCUSSION.

THE PRESIDENT:—Gentlemen, you have heard Paper No. 4, entitled "Stresses on Vessels of the Great Lakes Due to Wave of Varying Lengths and Heights," by Prof. Herbert C. Sadler, Member of Council, and Prof. Anders Lindblad, Member. This paper is now open for discussion.

MR. DAVID ARNOTT, *Member:*—This is a paper the importance and value of which must not be judged by the brevity of the text. Treating as it does of a type of vessel which is peculiarly a product of the ingenuity of the Great Lakes shipbuilders and a result of the wonderful development in the economic handling of bulk cargoes, the paper cannot fail to be of interest to those members of this Society who are naval architects. It is a matter for further congratulation that Dr. Sadler and Prof. Lindblad have seen fit to place on record in our Transactions the result of at least part of the investigation undertaken in connection with the work of the U. S. Load Line Committee.

In the design of any ship structure it is desirable, if undue waste of material is to be avoided, not only to know the maximum load to be carried but the most trying condition as to distribution of load and the kind of seas likely to be met with in the particular service for which the vessel is intended. Available data with regard to wave formations are unfortunately not so complete nor reliable as one could wish. We read about ocean waves having been encountered of a length five to the mile and of a height 40 to 45 feet, but such waves must be very rare indeed. It is extremely interesting therefore to have embodied in this paper the results of observations of waves actually encountered on the Great Lakes and to be assured that a wave 350 feet long and 20 feet high is the worst that we need consider. That the waves observed were relatively higher than ocean waves is what one would anticipate in view of the comparatively shallow depth of the Great Lakes, and in any determination of a suitable minimum freeboard for lake vessels it should be remembered that these short and steep waves are the most likely to break on deck. In a recent issue of one of the magazines, a Captain Buie, who claims to have sailed the Great Lakes for fifty years, stated that a wave that rose more than 8 feet above the surface (i. e., 16 feet from hollow to crest) was a mighty big wave for the Great Lakes.

No objection can be taken to the method of attacking the problem of investigating the strength of these bulk freighters adopted by the authors of this paper, but I would like to say a word regarding the conclusion, i. e., "That it appears that the lake freighters of today are for their service as strong if not stronger than similar ocean-going types." As a matter of fact there are no similar ocean-going types in existence nor, it is safe to say, in contemplation. These large, single-deck bulk freighters are a product of very special conditions, one aim in design being to obtain the maximum deadweight on a restricted breadth and draught with the result that the proportion of $\frac{L}{D} = 18$ as exemplified in the 580-foot vessel is considerably in excess of any merchant vessel engaged in overseas service.

Then again, in making any comparison with the strength of ocean-going vessels on the basis of the strength formula laid down by the British Freeboard Committee, it must be borne in mind that the proposed formula for longitudinal strength $\frac{I}{Y} = f\ b\ d$ is very definitely

limited in its application and that it was never intended to apply to ocean-going vessels of such extreme proportions. This standard section modulus was determined from an analysis made into the 1913 Rules of the various classification societies and is probably quite safe to use within the limits specified, although so eminent an authority as Dr. Bruhn seems to consider the standard somewhat low for vessels carrying heavy deadweight cargoes. Comparing the longitudinal strength of vessels on an $\frac{I}{Y}$ basis is convenient, but such a method can only be a safe guide in the determination of scantlings if their proportions of $\frac{L}{D}$ are somewhat similar, $\frac{I}{Y}$ not being a complete measure of the longitudinal strength as the relative stiffness to resist deflection is neglected. In other words, if the Freeboard Committee had been required to legislate for ocean-going vessels of proportions in the neighborhood of twenty depths to length, the standard laid down for longitudinal strength would probably have been very different.

I have had the M. I. of the section of a large bulk freighter 580 by 60 by 32 feet worked out and find that the $\frac{I}{Y}$ is 21,600 and that, on the basis of the freeboard strength standard for ocean-going vessels of ordinary proportions, the allowable draught would be about 17 feet. An addition of 45 square inches to the sectional area of the deck would satisfy the $\frac{I}{Y}$ standard for a draught of 19 feet, but the most optimistic naval architect would hardly be satisfied with this additional scantling to O.K. the vessel for operation in the winter North Atlantic in the ore trade. The point I wish to make is the necessity for caution in the application of the Freeboard Committee's strength standard to seagoing vessels having dimensions and proportions outside of the limits defined.

These big lake freighters are well designed for their intended service, i. e., the carriage of ore, coal and grain on the Great Lakes. The longitudinal structural strength, however, could be improved by extending the wing tanks to the deck, but this again would reduce the deadweight carrying capacity for grain cargoes.

One consideration which should not be lost sight of is the absence of serious deterioration through corrosive action in the steel hulls of lake vessels, and although a margin for corrosion is not evident in the strength standard of ocean-going vessels it is there nevertheless, so that on this ground alone lake vessels could have lighter scantlings and a lower initial strength standard.

It is in the practical effect of the proposals of Dr. Sadler as indicated in Plate 19 (Proposed Standard for Great Lakes Vessels) that I am especially interested. In applying these to the 580-foot vessel already mentioned and using an f value of 15 equivalent to a BM factor of 64 in association with a nominal stress of 8.2 tons, the allowable draught would be increased from 19 to 24 feet; and conversely, if the present draught of 19 feet were retained, a considerable reduction from the present topside scantlings could be allowed. It should be also remembered that in the application of the Freeboard Committee's standard the $\frac{I}{Y}$ in the way of a section abreast of the hatch openings is only required to be 90 per cent of the full standard expressed by $f \times b \times d$, and if it is Dr. Sadler's intention to allow a

similar concession, the allowable draught would be further increased to 26 feet 6 inches and still meet his proposed standard.

The nearest ocean-going vessels in type and dimensions to the big lake freighters are the 20,000 dead-weight ton Bethlehem ore boats designed by Mr. Frear, the dimensions being 550 by 72 by 44 feet and the maximum draught 32 feet. The machinery is located aft, and the deck erections consist of a poop and forecastle, also a short navigating bridge which does not contribute to the longitudinal strength of the vessel. The proportions of these vessels are moderate, being in the neighborhood of 12½ depths to length, and the longitudinal strength is in excess of the freeboard standard for ocean-going vessels of ordinary type. It would be interesting to have the statical bending moment diagrams published to compare with the data contained in Dr. Sadler's paper, and perhaps Mr. Frear could be persuaded to read a paper on the Bethlehem boats at our next meeting for the benefit of the members of this Society.

Rear Admiral David W. Taylor (C. C.), U. S. Navy, *Honorary Vice-President*:—Dr. Sadler is a member of the Load Line Committee, and, as chairman of its Great Lakes Sub-Committee, did an enormous amount of work, and I think this Society is to be congratulated that a small portion of that work will be published in the Transactions of this organization instead of buried in a government report.

The information with reference to the waves on the Great Lakes is exceptionally valuable, because there is very little information about this subject to be procured as a general rule. I had occasion some time ago to try to find out something along that line, and the only thing available that I could get hold of was a book published many years ago. It was valuable, but rather antiquated.

There is one matter I would like to call attention to, and that is the fact that the waves on the lakes have not the characteristics we assume for ocean vessels is not necessarily due to the shallow water. The shallow water of the Lakes has probably some influence, but I think you will find in every case that, as regards ocean waves, the shorter they are the steeper they are. The 250-foot wave would be a great deal steeper than a 500-foot wave. The waves formed as a storm sets in and begins to develop, are always shorter and steeper on the ocean as well as on the Lakes than the long, low waves after the storm has passed.

Professor Sadler:—In answer to Mr. Arnott, I mean, of course, by similar vessels, cargo vessels. I was not comparing the cargo vessel with the Leviathan or anything of that character. The lake vessels are not built to sail on the ocean. When I said that lake vessels were as strong as some ocean-going types, I meant taking it from our standpoint of strength. We have usually taken a vessel poised on the crest or in the hollow of a wave of her own length, and one-twentieth of that length, in height, as the standard for ocean-going types. That is an arbitrary standard, and from that we have established certain arbitrary stresses. I know of several ocean-going vessels classed in registry societies where the stress exceeds 10 tons per square inch at the top of the shear strake; in no case do the lake vessels approach that figure. I think the highest we got was 7.5. That is what I meant by the comparison, showing that we still have a good deal of margin to spare.

I want to clear up one misconception. I think it is a pity that those who are discussing or considering types of vessels designed for special purposes should be continually comparing them with ocean-going types. It is not necessary, except so far as information obtained from ocean-going types of standard stresses could be made use of and applied.

With the reference to the sections through the hatches, of course, there is no such thing as a section through a hatch in a lake type vessel. Mr. Arnott must be aware of that. The only deck we have on a lake vessel is the stringer plate on each side. There is no other deck on the ship, and there is no section through the hatches. In fact the ship consists of practically one hatch, and therefore no further concessions on draught would be allowed, as suggested in the British Report for Ocean Ships.

In regard to Admiral Taylor's remarks, I think his explanation as to waves is undoubtedly correct. It is not necessarily due to the fact that the water is shallower that we get the steeper wave.

I might add, in conclusion, that the captains of a number of the Great Lakes vessels took a large number of observations. They cooperated with us in the best possible way, and we drew up a series of suggestions for them as to how they should observe the heights and lengths of waves, and in some cases they were very careful in their observations. The longest waves observed, as I mentioned in the paper, 400 feet, were unfortunately taken by one observer only, and when you figure the speed of a wave 400 feet it is easy to make mistakes tc the extent of 100 feet, if you miss the passage of time when that wave is on the crest by one second.

THE PRESIDENT:—Gentlemen, I am sure you all wish me to extend the thanks of the Society to Professor Sadler and Professor Lindblad for this very valuable contribution to the records of the Society, and I take pleasure in so doing.

This concludes the morning session. We will take a recess until 2.45 o'clock this afternoon.

The meeting then adjourned.

SECOND SESSION.

WEDNESDAY AFTERNOON, NOVEMBER 8, 1922.

President McFarland called the meeting to order at three o'clock.

THE PRESIDENT:—The first business of the afternoon session is the consideration of Paper No. 3, entitled "The Application of Dyson's Method to Propellers of Ocean-Going Merchant Vessels," by Mr. Edwin A. Stevens, Jr., Member. I want to say again, for the benefit of all, that authors in reading their papers are requested to abstract them as far as possible. We have three papers to consider this afternoon, and it is likely that they will all bring out more or less discussion, and if we want to have plenty of time for the discussion, the papers must be abstracted.

Mr. Stevens then presented his paper.

THE APPLICATION OF DYSON'S METHOD TO PROPELLERS OF OCEAN-GOING MERCHANT VESSELS.

By E. A. Stevens, Jr., Esq., Member.

[Read at the thirtieth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 8 and 9, 1922.]

During the transactions of this society in 1920, Admiral C. W. Dyson presented a paper entitled "The Problem of the Hull and its Screw Propeller," in which a number of examples were shown. These were all navy vessels with the exception of the first problem. It has been claimed by many that, while this method is very accurate for these vessels, especially those fitted with twin screws, the block coefficients of which do not exceed 0.65, it might not be applicable to merchant ships with full lines and fitted with one propeller. The writer will present in this article several ships of this type, together with other types of merchant ships, and show the results of Dyson's analysis, together with the results obtained on the trial trips. Another argument used against this method is that while the anticipated power and revolutions obtained by the calculation compare favorably with those developed on the trial trip, the same cannot be said regarding the power and revolutions per minute obtained at sea. This, however true it may be, is not due to the method but to the way it is used. In the latter case, an addition of 20 to 30 per cent should be made to the effective horse-power of the ship as found from the model test.

Before attacking any of the problems it might be well to mention one thing. The basic slip (S) is dependent not only on the corrected block coefficient but also on the ratio of twice the length of after body divided by the draught. In a few cases coming to the writer's attention, it was impossible to obtain the length of after body. In order to make a reasonable estimate of this length, about forty-five ships were plotted with block coefficients as abscissas and length of after body divided by length between perpendiculars as ordinates. These varied considerably, but a fair average would be as shown in the following table:

B. C.	$\frac{\text{L. A. B.}}{\text{L. B. P.}}$	B. C.	$\frac{\text{L. A. B.}}{\text{L. B. P.}}$
0.60	0.50	0.725	0.407
.625	.494	.750	.376
.65	.48	.775	.339
.675	.46	.80	.302
.700	.436	.825	.265

If the ship is fitted with a cruiser stern, the length of water line should be used in place of length between perpendiculars.

If the above table is used for obtaining the length of after body, quite accurate results will be obtained as, in the majority of cases, it requires a material change in the basic slip to appreciably affect the revolutions.

The various problems may be divided into three groups: (1) Single-screw vessels; (2) vessels fitted with two or more screws, the wing screws being carried in struts; (3) vessels fitted with two or more screws, the wing screws being carried in bosses or spectacle frames.

GROUP 1.

Problem 1, Plate 20.—The ship used in this problem is the S. S. Gulfprince, the trials of which were described by Mr. H. A. Everett in his paper entitled "Power and Speed Trials of Ten Thousand Deadweight-Ton Tanker," which was published in last year's volume of the transactions of this society. It will be noticed that the actual power is less than the calculated at the higher speeds, while at the lower speeds the reverse is the case. As the after body is quite long, the value of K is probably less than that shown on the chart, while the increase in actual power of the lower speeds in relation to that calculated is undoubtedly due to the falling off of the mechanical efficiency of the engine at the lower powers.

Problem 2, Plate 20.—As this model had never been tested in the tank, no effective horse-power curves were available. The revolutions estimated (by using the indicated horse-power developed on the trial) compare favorably with those obtained on the trial. Calculations were then made for the effective horse-power which also compare favorably with an estimated effective horse-power obtained by using Taylor's method. The resistance per ton of displacement was taken from a ship of the following dimensions: L. B. P., 380; beam, 53; draught, 24; displacement, 10,900 tons; block coefficient, 0.79; M. S. coefficient, 0.988.

Problem 3, Plate 21.—This ship was fitted with geared turbines. Unfortunately, no torsion meter was installed, but the shaft horse-power was estimated from curves supplied by the manufacturer of the turbine. The vessel was first run on a twelve-hour trial, during which the following were the average pressures and temperatures:

Pressure at throttle	186 lbs. gauge.
Pressure at nozzles	182 lbs. gauge.
Superheat	Not given.
Temperature at exhaust	96.3° F.
Vacuum corresponding to 96.3° F.	28.3.
S. H. P. from curves	2,500.

Progressive runs were then made over the Provincetown course with the following results:

Speed in Knots	*R. P. M.*
6.355	50.075
8.055	64.05
9.511	74.00
11.447	89.37

From this the speed on the twelve-hour run was estimated to be 11.38 knots.

It will be noticed that while the R. P. M. on the trial practically agree with the analysis, there is quite some difference in the horse-power. This might be explained by the fact that, the propeller being a cast-iron wheel, the roughness of its surface added at least 2 to 3 per cent to the power, while the remainder may be due to a slight inaccuracy of the gauges and

thermometer or a difference between the superheat obtained on this trial and that for which the curves were drawn.

Problem 4, Plate 21.—As there was no measured mile within reasonable distance, the run was made from Ambrose Light Ship to Fire Island Light Ship and return. The revolutions were held as near constant as was possible, and indicator cards were taken every fifteen minutes. While the results are not as accurate as if the run had been made over a measured mile, it is believed they are sufficiently accurate to warrant presenting them in this paper. There was a very slight swell and a breeze of not over 3 knots during the trial.

Problem 5, Plate 22.—The data for this problem were taken from "Notes on the Performance of S. S. Tyler," by Mr. E. H. Rigg, published in Vol. XX of the transactions of this society. The data given as actual I. H. P. and R_d are those observed on the trial runs. If those of the faired curves had been given the actual I. H. P. for 12.233 knots would have been 1,480 and the actual R_d would have been 90.8, and for 9,876 knots the actual I. H. P_d and R_d would have been 790 and 73.2.

Problem 6, Plate 22.—The power and revolutions as given by an analysis did not agree with those obtained on the trial. As the difference was so great, an investigation was made as to the causes. It was found that the wheel was working in cavitation and the effective horse-powers were greater than those shown on the curves. An analysis was made for revolutions (using the I. H. P. from the trials), which check with those obtained on the runs. The effective horse-powers were then calculated and compared with those of Model 1013, the block and midship section coefficient and dimensions of which are the same as this ship. The length of after body was the same, while the middle body of Model 1013 was slightly less and the fore body slightly longer. The forward sections of the ship were more of the U shape, and the after sections had more of a club foot than the model. According to experiments conducted by Professors H. C. Sadler and E. M. Bragg, the results of which were published in last year's transactions, it would appear that Model 1013 would require slightly less power for these low speeds. This would only partly account for the difference; the remainder would probably be caused by the condition of the ship's bottom. The vessel was drydocked and then loaded, after which the trial was run. The time between drydocking and the trial was about three weeks.

Problem 7, Plate 23.—The results of the trials at two speeds of three ships of the same design, together with the analysis, are given in this problem. No effective horse-power curves were available. The revolutions were calculated using the indicated horse-power. The effective horse-power was then calculated and compared with that estimated.

GROUP 2.

We will now pass to the second group; namely, ships fitted with more than one screw, the shafts of the wing propellers being carried in struts. The first two, Problems 8 and 9, are the navy colliers Jupiter and Cyclops. While these are not merchant ships, their forms are very similar to moderate-speed freighters or to slow-speed passenger and cargo ships and are included in this paper for lack of other available data.

Problem 8, Plate 23.—As the writer was not in possession of the length of after body of this ship, an estimate was made using that of the Cyclops (Problem 9, Plate 24).

Problem 10, Plate 24.—This ship had been in the water for some time before the trial,

which accounts for the difference in horse-power between the estimate and that obtained on the trial. Unfortunately indicator cards were not taken on the mile run, but were taken after the same. The average power was 6,155 and average revolutions 102.75. Assuming the power to vary as the cube of the revolutions we have $6{,}155 \times \left(\frac{104.75}{102.75}\right)^3 = 6{,}540$, which is used as the indicated horse-power on the mile course. If this figure (6,540) was used in the calculations for slip in place of the estimated power, R_d would have been 102.8 in place of 101.8.

GROUP 3.

When the wing shafts are carried in bosses, the basic slip seems to be affected if the bosses are horizontal or nearly so, as will be shown in Problem 12.

Problem 11, Plates 25 and 26.—Unfortunately, no trials were run on these ships at the designed deep draught of 30 feet. The model was tested at three draughts with model propellers, the results of which are used in Plates 25 and 26. While the powers check very closely in all three cases, the estimated revolutions at 36-foot draught do not agree with those obtained from the model test. As this draught (36 feet) is four times the height of the center of propeller above the base line, this might be considered as a deep-draught vessel with propellers carried as deeply as possible, which condition is not covered in Admiral Dyson's latest work. A correction should be made for obtaining the basic slip. The writer is not prepared to say just how this should be made, but two ways are possible; first, taking the slip block coefficent and basic slip at a lighter draught, or second, by using a line on the block coefficient chart passing through the lower left-hand corner of the chart and cutting the right-hand side somewhere above line X. The slip block coefficient would then be less and the basic slip greater than what it would be by using line X.

A trial was run on a ship similar to this but fitted with different propellers, the results of which are shown on Plate 26. It will be noticed that, while the revolutions agree, there is some difference in the power. This was caused by the run being made on the Delaware Breakwater Course. The lack of deep water affects the power but does not seem to vary the revolutions for given speeds. This was shown by tests conducted by the U. S. Navy on the battleship Michigan, which was run over the Rockland, Provincetown and Delaware Breakwater courses. While the revolutions for various speeds were practically the same on all the courses, the power varied considerably. As the draught and range of speed of the two ships are practically the same, it would be safe to consider that, had this ship been tested in deep water, the power developed would have been very close to that estimated, while the revolutions would be the same as those obtained on this trial.

The propeller shafts of both model and ship were carried in bosses set at about 32° with the horizontal plane, the intersection of which with the hull was probably parallel or nearly parallel with the stream lines.

Problem 12, Plate 27.—The angle between the bosses and the horizontal plane on this ship was about 10 to 15° which, as will be seen in the calculation, seems to affect the basic slip. The revolutions were first calculated using the value for slip block coefficient as given on line X, then using line Y. In the former case the calculated revolutions were greater and in the latter they were less than those obtained on the trial. By using a value between these two, the calculated R_d worked out almost the same as the actual R_d. On account of lack of data, the value of K cannot be determined, but an estimate was made of the ef-

fective horse-power by the Taylor method and by calculation from the propeller data. There was quite some difference between these, which would be accounted for if the draught during the trial (which is not known) was less than 29 feet.

Problem 13, Plate 27.—For the same reason as mentioned in Problem 4, this ship was run from Ambrose Light Ship to Fire Island Light Ship and return. Unfortunately, the only effective horse-power curve available was for a draught of 28 feet 2 inches. Assuming the effective horse-power to vary as a means of the ratios of the displacements and the displacements to the two-third power, we have:

Displacement at 28 ft. 2 in.	16,900
Displacement at 24 ft. 0 in.	14,250
$(14{,}250 \div 16{,}900)^{2/3}$	0.894
$14{,}250 \div 16{,}900$	.844
Mean	.869

E. h. p. (28 ft. 2 in. draught) at 11.64 knots = 1,860.
E. h. p. (24 ft. draught) at 11.64 knots = $1{,}860 \times 0.869 = 1{,}615$.

The above powers included the resistance of the rudder and bilge keels but not the propeller bosses which is estimated at 80, making a total effective horse-power of 1,695. This vessel was fitted with Diesel engines, the mechanical efficiency of which was about 75 per cent.

The angle of the bosses with the horizontal plane was about 20 degrees.

Problem 14, Plate 28.—This ship is the Great Northern, the trial-trip data of which were published in the *Journal of the American Society of Naval Engineers.* The values of effective horse-power, which were obtained by multiplying the shaft horse-power by the propulsive coefficients as shown on the trial curves, are probably that for the bare hull, as the propulsive coefficients are quite low and as the propellers are apparently out of cavitation. The revolutions were calculated using the shaft horse-power from the trial data, and compared with the actual revolutions. Calculations were then made for the effective horse-power. The difference between the calculated effective horse-power and those obtained by multiplying the shaft horse-power by the propulsive coefficients could be taken as the power required for the appendages.

CONCLUSION.

In the foregoing are represented almost every type of seagoing merchant ships. Problems 1 to 7 are single-screw ships and, with the exception of Problem 5, have full lines, the block coefficients being over 0.77. Problem 13 is a full-bodied cargo ship with twin screws. Problems 8, 9 and 10 are of the slow cargo and passenger type or moderate-speed freighter, fitted with twin screws. Problem 11 is a moderate-speed cargo and passenger ship, while Problems 12 and 14 represent high-speed passenger vessels. The vessel in Problem 5 was built for the coast trade between New York and Norfolk. When loaded to her deep draught (about 22 feet) her underwater body was similar to a moderate-speed cargo and passenger vessel with single screw. At the draught at which the trial was run (16 feet 11 inches), the underwater body was more like a sound or river steamer with a full midship section.

The writer regrets that he had to include in this paper examples where either very accurate or full information was not obtainable, but was obliged to do so because of the lack of more complete data.

DISCUSSION.

THE PRESIDENT:—Gentlemen, Paper No. 3, entitled "The Application of Dyson's Method to Propellers of Ocean-Going Merchant Vessels," by Edwin A. Stevens, Jr., Member, is now open for discussion.

MR. WILLIAM W. SMITH, *Member*:—On page 85, the author states that 20 to 30 per cent should be added to the ideal effective horse-power to obtain the effective horse-power at sea. I think this is a very good average allowance, but sea conditions vary widely, and the power might be considerably more or less. With such widely varying conditions, no method of estimating can predict the performance very closely for all conditions.

Referring to the last paragraph on page 89, it seems to me that a valuable feature of the Dyson method is that it can be used with data of this character, which, I regret to say, we have to use very often, especially for merchant vessels.

The author appears to be justified in his conclusion that the Dyson method is quite accurate for merchant type vessels. The trial results check very well indeed with the estimated performance. I would suppose from the nature of these trials that there would be appreciable errors of measurements, etc., which no doubt accounts for some of the differences.

These analyses are further proof of the reliability and accuracy of the Dyson method. As far as I know, it is the only completely organized practical method for designing and analysing propellers. Also, it is the only method where the estimated performance checks closely with the trial results. Further it is the only method where size, speed and cavitation are fully provided for.

Propeller estimates to be reliable must be based on standard data from actual trials. Model tests alone can never be conclusive without the proof of trial analyses of this kind. Model data would increase greatly in value if verified in this manner.

Trial analyses of this kind are of great practical value in estimating the performance of propellers, and it is hoped that the Society will encourage members to present papers of this nature.

Mr. Stevens deserves the thanks of the Society for preparing this very interesting and valuable paper.

REAR ADMIRAL CHARLES W. DYSON, *Member of Council* (Communicated):—Referring to the first paragraph where it is stated that the method has been criticised because that, while the anticipated power and revolutions obtained by the calculation compare favorably with those developed on the trial trip, the same cannot be said regarding the power and revolutions obtained at sea, the author's explanation of this is perfectly satisfactory. It is very queer that people cannot understand that, where a propeller is designed for a certain condition, the revolutions and power estimated for this condition cannot be expected to be realized when the ship is loaded down several feet deeper in the water than on the trial and designed conditions.

Referring to the effect of spectacle frames, my experience has been that, where the fin of the spectacle frame is horizontal, or nearly so, the basic slip of the hull is very much decreased from that which would exist were struts used instead of the spectacle. Also the K factor is reduced so that the new K factor equals the normal K factor of the hull to 1/7

power. As the angle of the fin is increased until it finally reaches the vertical, in this latter position the revolutions are those which would be obtained in cavitation while the K factor becomes squared. Where the fin is so located as to have no directive force on the water flowing to the screw or to interfere with the water closing in around the hull, its effect on basic slip and K is nil.

In the problem of type 2 ship, loaded down very deeply, her revolutions are considerably below those actually obtained. In type 2 ships I have found it better to make no correction as the ship is loaded down, but to use for H the height from the base line to the upper limit of the stream-line body. Any increase in block above this has no effect on the revolutions, but it does effect the value of K.

Mr. Stevens:—In answer to Admiral Dyson's remarks the following should be mentioned: The 20 to 30 per cent that should be added to the effective horse-power, as found in the model test, is to allow for the increased resistance of a ship at sea over that on the trial trip. This increase is not intended to allow for any difference in the draught, but that due to the foulness of the ship's bottom and to adverse weather conditions.

I might state here, on analysing the data on various voyages of vessels, that the increased power at sea seems to run anywhere from 15 to 40 per cent over that on the trial trip, depending on the weather and the condition of the ship's bottom. A fair average would be about 25 to 30 per cent. The U. S. Navy has found that after a ship has been in the water a month, the increase due to the roughness of the ship's bottom is about 10 per cent.

Referring to ships fitted with spectacle frames, Admiral Dyson's experience seems to confirm mine, when the fins follow the stream line and when they are horizontal or nearly so, in as far as they effect the slip.

Referring to Problem 12, if the estimated effective horse-power (as calculated by Taylor's method of hull resistance) is correct, the K value for this ship would be about the one-half power of that shown on the chart. From Admiral Dyson's experience regarding the effect that the bosses have on the power augment factor K, it would seem advisable to place the fins horizontal or nearly so, if by so doing the resistance of the ship is not increased enough to counterbalance the reduction of the power augment factor. It appears that this question would be well worth studying, as the necessary power might be considerably reduced by the proper placing of the fins, or by using spectacle frames in place of the struts.

All that I can say about Mr. Smith's remarks is, that his ideas and mine are too much alike to permit of any discussion.

The President:—We thank you, Mr. Stevens, for reading the paper. I am sure that all the members have been highly interested in its statements. It takes us back to old times to have Mr. Stevens present a paper to us, gentlemen; his father used to read valuable papers before this Society, and it is a fine thing now that the son has taken up the work in the footsteps of his father, and that his father's mantle has fallen on his shoulders.

The next two papers on the program, Nos. 5 and 6, are along similar lines, and if they are presented and considered together, we shall have the best results in the discussion. We will therefore call for Paper No. 5, entitled "A Study of the Wake of Certain Models by means of a Current Meter," by Professor Edward M. Bragg, Member.

A STUDY OF THE WAKE OF CERTAIN MODELS BY MEANS OF A CURRENT METER.

By Professor E. M. Bragg, Member.

[Read at the thirtieth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 8 and 9, 1922.]

Our knowledge of the wake of models has been obtained by means of Pitot tubes and from experiments upon self-propelled models.

The objection to the Pitot tube is that it gives the wake value for a filament of water while the propeller works in a column of water whose average wake value is wanted, and the integrated value of the filament wakes is uncertain.

The self-propelled model results give values of wakes for conditions similar to those in which the full-sized propeller is to work, but any extensive search of the wake involves a great amount of labor and expense. Further, the wake value depends upon the assumption that, given the relation between thrust, slip, and speed of advance for a propeller tested in the "open" condition, the same thrust and speed of advance when working behind a model is accompanied by the same slip. This may be very nearly true in the case of twin screws behind fine models, but I doubt very much if it is true for single screws behind models with full sterns.

In the "open" test the water is flowing parallel to the center line of the screw shaft and the velocity is uniform over the area swept by the screw. In the "behind" test the water is closing in and rising up around the stern of the model, the flow is anything but uniform in the area swept by the propeller, and the conditions are such that the propeller efficiency may be greater or less than that obtained in the "open" test, as results given later will show.

The results given in this paper were obtained by means of a current meter fitted with wheels of varying diameter. A photograph of the meter and wheels is shown on Plate 29. The experiments extended over a considerable length of time, and it could not be foreseen in the beginning just what conditions might be met with later on. A position for the meter wheel was chosen which could be obtained in any model which might be available for testing purposes. This position will be referred to as the "test" position and was such that the hub of the meter wheel was 0.375-inch back of the rudder post.

When the meter wheel was off to one side of the center line of the model there was probably a slight slewing of the wake in that direction, due to the obstruction offered by the meter wheel, but I do not believe it was sufficient to affect the results materially.

Since the meter wheels were not exactly in the position that the propellers would occupy, it should be kept in mind that the wake values here given are for comparative purposes only, and certain corrections would have to be made for fore and aft position and probably for scale before they could be used for design purposes.

The models were tested at speeds ranging from 140 feet per minute to 200 feet per minute in the case of Models 1130, 1131, 3, 4, and 5; from 150 to 250 feet per minute in the case of the 10-foot plane and Models 1 and 2; and from 130 to 175 feet per minute in

the case of Model 6. In the fine models the wake showed a slight tendency at times to decrease as the speed increased. In the full models the wake was constant up to 200 feet per minute, but at higher speeds there was often a marked increase in the wake, due probably to the position of the stern wave.

Previous papers dealing with the subject of wake have pointed out that the value of the wake will vary with the diameter of the wheel used, with the fore and aft position, and with the transverse position of the wheel. In this paper attention is called particularly to the effect upon the wake of variation in the immersion of the wheel, whether by changing draught with fixed position of wheel relative to keel or by changing the position of the wheel relative to the keel with the draught fixed. Attention is also called to the effect of variation in the form of the model.

Results are given for a 10-foot varnished wooden plane, for a series of four wax models with constant length of entrance and varying length of run (see Model 1130), for a series of five wax models with constant length of run and varying length of entrance (see Model 1131), and for six wax models with no family relation (see Models 1, 2, 3, 4, 5, 6). The characteristics of the various models dealt with are given in Table I.

In the 1130 series the meter wheels were 2.75 inches, 3.75 inches, and 5 inches in diameter. Tests were made at two draughts with the wheels on the center line only.

In the 1131 series the wake was measured with wheels 3.75 inches, 4.5 inches, and 5.375 inches diameter, at one draught only, but with the wheels on the center line and also 2.75 inches off the center line. Certain of the models were tested with the wheel centers 1.75 inches up from the keel, and certain others with the wheels 2.75 inches up.

The models of the 1131 series were somewhat finer than those of the 1130 series, but it would appear from Figs. 2 and 4, Plate 30, that variations in the length of entrance do not produce as much change in the wake values as variations in the length of run.

The lines of the 1130 and 1131 series were upon the whole quite good, especially the 1131 series. The 1130 models had V-shaped stern sections and medium bow sections. The 1131 series was based upon the 1130 series (see Proceedings of Naval Architects and Marine Engineers of 1921) and had the combination of bow and stern section shape which seemed to give the best results, namely, V-shaped bow sections and somewhat U-shaped stern sections. A glance at Figs. 1 and 3, Plate 30, will show the difference in section shape. The full lines in the body plans are stern sections and the broken lines are bow sections. The numerals on each section indicate the number of inches from the section to the nearest perpendicular.

Fig. 1 gives the location of sections for Model 1130*c*; the stern sections were closer to the aft perpendicular in Models *a* and *b*, and more widely spaced in Model *d*.

Fig. 3 gives the location of sections for Model 1131*b*, while the bow sections of Model *a* were closer to the forward perpendicular, and in Models *c*, *d*, and *e* were more widely spaced.

The difference in the shape of the stern sections, and the smaller beam-draught ratio in the case of 1130 models probably accounts for the wake values being lower for this series than for the 1131 series. The sharper sections aft in Model 1130 kept the wake water with the greatest forward velocity farther away from the meter wheels than in the case of Models 1131, even though the meter wheels were the same distance from the keel.

Models 1, 2, 3, 4, 5, and 6 were of varying degrees of excellence as regards shape of

TABLE I.

	Length ft.	Breadth ins.	Draught ins.	Wet surf. sq. ft.	Disp. lbs.	Area of mid-ship section sq. ins.	Per cent of Ent.	Per cent of Middle body	Per cent of Run	Block coef. C_B	Prism. coef. C_P	Mid-ship coef. C_O	Load-water line coef. C_{WL}	$\frac{C_B}{C_{WL}}$	Prism. coef. of after body
1130*a*.....	9.66	15.27	7.57	21.28	396.6	113.8	27.1	48.6	24.3	.822	.836	.985	.901	.912	.855
a.....	....	....	6.75	19.91	349.5	101.2	....	....	....	.812	.827	.983	.892	.911	.833
b.....	....	....	7.57	21.05	384.6	.....	27.1	40.5	32.4	.798	.811	....	.891	.894	.799
b.....	....	....	6.75	19.64	337.7	.....	....	....	....	.784	.798	....	.881	.891	.779
c.....	....	....	7.57	20.83	372.7	.....	27.1	32.4	40.5	.772	.785	....	.882	.876	.743
c.....	....	....	6.75	19.39	326.5	.....	....	....	....	.758	.771	....	.869	.871	.724
d.....	....	....	7.57	20.58	360.6	.....	27.1	24.3	48.6	.748	.76	....	.872	.858	.686
d.....	....	....	6.75	19.09	314.5	.....	....	....	....	.731	.744	....	.858	.851	.668
1131*a*.....	9.66	16.5	6.75	20.6	358.5	109.5	23.8	35.7	40.5	.769	.782	.983	.856	.90	.724
b.....	....	....	6.75	20.3	353.5	.....	27.1	32.4	40.5	.758	.771	....	.848	.893	.724
c.....	....	....	6.75	20.1	343.2	.....	33.9	25.6	40.5	.736	.748	....	.832	.883	.724
d.....	....	....	6.75	19.65	332.5	.....	40.7	18.8	40.5	.713	.725	....	.816	.873	.724
e.....	....	....	6.75	19.35	321.0	.....	48.5	11.0	40.5	.688	.700	....	.797	.862	.724
Model 1.....	10.0	16.0	6.26	15.65	222.5	84.4	50.0	0	50.0	.515	.610	.844	.72	.716	.60
			6.96	16.95	257.0	95.8	50.0	0	50.0	.535	.622	.86	.735	.728	.618
			7.66	18.22	295.0	106.7	50.0	0	50.0	.555	.637	.871	.755	.735	.633
Model 2.....	10.0	17.83	6.4	19.92	345.0	111.7	40.0	13.0	47.0	.70	.715	.979	.831	.842	.683
			7.2	21.33	394.0	126.0	40.0	13.0	47.0	.71	.724	.981	.848	.837	.701
			8.0	22.7	445.0	140.3	40.0	13.0	47.0	.72	.732	.984	.863	.834	.718
Model 3.....	10.4	16.9	6.0	21.25	361.0	99.6	27.4	35.0	37.6	.79	.803	.98	.87	.909	.775
			6.81	22.45	417.0	113.3	27.4	35.0	37.6	.80	.815	.984	.883	.907	.786
			7.56	23.45	469.5	126.0	27.4	35.0	37.6	.81	.822	.987	.894	.906	.795
Model 4.....	10.5	15.9	6.58	21.3	379.0	102.6	32.5	33.3	34.2	.798	.813	.981	.871	.916	.808
Model 5.....	10.0	16.3	7.07	21.64	399.0	113.7	30.0	40.0	30.0	.802	.814	.984	.872	.919	.807
Model 6.....	10.1	15.72	7.0	21.05	399.0	108.6	23.0	50.0	27.0	.832	.843	.987	.86	.968	.818
Varnished plane	10.0	0.75	7.0	12.5	.....	5.25	....	....	....	....	....	....	....	....	.....

sections and portion of length devoted to run and entrance. An idea of the difference in the shape of the models can be obtained from Figs. 5, 10, 14, 18, 22, and 24, Plates 31, 32, 33, 34 and 35.

Table II gives the ratio of total resistance of model to frictional resistance at speed-length ratios of .5 and .6. The information given in Tables I and II, together with the body plans, shows that Models 1, 2 and 3 were of good form both as regards section shape and

TABLE II.

	Length	Draught	Total resist. ÷ Frict. resist.			
			Naked		With bossing	
	Ft.	Ins.	$\frac{V}{\sqrt{L}}=.5$	$\frac{V}{\sqrt{L}}=.6$	$\frac{V}{\sqrt{L}}=.5$	$\frac{V}{\sqrt{L}}=.6$
Model 1.....	10.0	6.96	1.21	1.21	.....	.....
2.....	10.0	7.2	1.21	1.22	.....	.....
3.....	10.4	6.81	1.25	1.29	1.25	1.32
4.....	10.5	6.58	1.31	1.41	1.31	1.41
5.....	10.0	7.07	1.35	1.40	1.32	1.38
6.....	10.1	7.0	1.75	1.83	1.61	1.69

longitudinal distribution of displacement. Model 6 (see Fig. 24) was more or less of a monstrosity; the shape of sections was bad and the length of run was so short that the driving qualities of the model were materially improved by the addition of bossing. This was true to a less degree of Model 5, while Model 4 was on the ragged edge.

The results of wake tests upon Model 1 are shown in Figs. 6, 7, 8, and 9, Plate 31. The wake was searched with a 2.75-inch wheel at three different heights and at three transverse positions, and the results are shown in Fig. 6. This figure shows the line which the center of the meter wheel must follow for constant wake value. The horizontal and vertical scales are not the same, so that the lines appear flatter than they should. The lines rise at an angle of about 45 degrees. The wake of Model 1130*c* was searched in the same way and the results for this fuller model were of the same general character, the lines of constant wake values rising a little more sharply.

Figs. 11, 12, and 13, Plate 32, give the reults of tests upon Model 2. Models 1 and 2 were not tested with bossing.

Model 3 was tested with three sizes of meter wheels at three draughts and three heights of meter wheel above keel for the single-screw condition, but at only two heights above keel for the bossed condition. It will be noticed in Figs. 15, 16, and 17, Plate 33, that for the same immersion of center of meter wheel the wake will vary, depending upon whether the draught is constant with position of meter wheel varied vertically relative to keel, or whether the draught is varied with the meter wheel at a fixed height above the keel. The wake is much more constant in the latter case. The full lines are for the single-screw condition, and the broken lines are for the twin-screw condition with bossing. When the meter wheel is on the center line the general effect of bossing is to decrease the wake, the decrease being considerable in the case of the small wheel, but it does not amount to much in the case of the large wheel.

When the wheel is out from the center line the wake in the bossed condition is greater than when there is no bossing, and the difference is not affected much by the change of diameter.

In general the effect of bossing seems to be to even up the wake, making it less at the center line than in the single-screw condition and greater in the way of the bossing.

Figs, 19, 20, and 21, Plate 34, give the results of tests upon Model 5, which was tested at only one draught. The results are in general accord with those of Model 3, which had much better lines. In testing this model the meter was placed below the line of the keel and showed a wake of 5 per cent when down a distance equal to about one-third the draught.

The left-hand portions of Figs. 19, 20, and 21 give the increase in wake due to variation in fore and aft position of the meter wheel. Moving the meter wheel forward from the test position to about the position which the propeller would occupy on a single-screw vessel increased the wake by about one-fourth. In the twin-screw position the increase due to moving forward from the test position amounted to about one-fifth.

Models 4 and 6 were not tested as extensively as the others. Fig. 23, Plate 35, shows the variations of wake for Model 4 as the meter wheel is varied in diameter. It will be noticed that the variation is quite marked in the single-screw condition, but that the variation is much less in the twin-screw condition. In the single-screw condition the small wheel is in a region of maximum wake, but an increase in diameter brings the tip of the wheels out into regions of less disturbed water. This causes the average wake value to decrease quite rapidly with increase in diameter. In the twin-screw condition increase in diameter causes the tips of the blades to reach out into a region of high disturbance on one side and into a region of low disturbance on the other, and the result is a fairly uniform value of the wake for varying diameter. The results for Models 3 and 5 when plotted upon diameter show this same general variation.

Fig. 25, Plate 35, gives the results of tests upon Model 6. In this case the bossing did not seem to decrease the wake on the center line, even though it did cause the model to drive easier. In this test the meter was carried down to a depth of 7 inches below the line of the keel, and a wake of 2.5 per cent was registered with a 3.75-inch wheel.

Fig. 27, Plate 36, shows the results of tests with a 3.75-inch meter wheel upon Models 1, 2, 3, 5, and 6, and also upon a 10-foot varnished plane. The conditions for all the models were not exactly the same but were very close, as shown by Table III.

TABLE III.

	Length Ft.	Breadth B Ins.	Draught H Ins.	$\frac{B}{H}$	C_B	C_{WL}	$1-\frac{C_B}{C_{WL}}$	$\frac{\text{Run}}{\text{Length}}$
Model 1.....	10.0	16.0	6.96	2.3	.535	.735	.272	.50
2.....	10.0	17.83	7.2	2.48	.71	.85	.165	.47
3.....	10.4	16.9	6.81	2.48	.80	.88	.09	.376
5.....	10.0	16.3	7.07	2.3	.80	.87	.08	.30
6.....	10.1	15.72	7.0	2.25	.83	.86	.034	.27
Varnished plane..	10.0	0.75	7.0	0.1	....	....	....	....

Fig. 27 would seem to indicate that certain variations in wake values can be linked up with the vertical prismatic coefficient (see appendix). This quantity will give an indication of the fineness of the lower water lines which control the direction of flow of a considerable part of the wake water, and the quantity $1-\frac{C_B}{C_{WL}}$ will be a function of the virtual rise

of floor and will be connected more or less intimately with the height of center of gravity of wetted surface.

The lower the center of gravity of the wetted surface the stronger will be the wake near the keel. A large part of the wetted surface is below the upper turn of the bilge. In full vessels this portion of the wetted surface may constitute from 0.5 to 0.65 of the total. In the dead flat alone the surface will be from 0.25 to 0.33 of the total.

The curve for Model 6 in Fig. 27 shows that as the stern gets more box-like there will be a region of high wake near the keel. As the virtual rise of floor increases this point of maximum wake is higher. In Model 6 a maximum occurs at about 0.2 of the draught, in Model 5 at about 0.48 of the draught, in Model 3 at about 0.55 of the draught.

While this variation of wake along a vertical plane through the center line of the model is most marked when the small meter wheel is used, it also exists when the larger wheels are used. The curves of wake values for Models 1, 2, 3, and 5 are sufficiently complete to enable the wake to be obtained for identical conditions in the above models.

Let B = breadth of model.
H = draught of model.
E = elevation of center of meter wheel above keel.
D = diameter of wheel.
Let the identical conditions be:

$$\frac{B}{H} = 2.31. \qquad \frac{D}{H} = 0.76. \qquad \frac{E}{H} = 0.39.$$

These are close approximations to the conditions that will exist in ordinary cargo vessels when loaded.

Table IV shows the results obtained from cross curves.

TABLE IV.

$\frac{B}{H} = 2.31.$ $\frac{D}{H} = 0.76.$ $\frac{E}{H} = 0.39.$

	Draught H Ins.	Diam. of wheel D Ins.	Elev. of meter above keel E Ins.	Wake %	Run / Length	$\frac{C_B}{C_{WL}}$	Prism. coef. of after body
Model 1.....	6.94	5.28	2.7	18.7	.50	.728	.616
2.....	7.74	5.88	3.02	21.5	.47	.835	.712
3.....	7.34	5.58	2.85	31.7	.376	.904	.792
5.....	7.07	5.375	2.75	33.0	.30	.919	.807
6.....	6.81	5.18	2.66	45.7	.27	.967	.818

Fig. 26 shows the wake values given in Table IV plotted upon the longitudinal prismatic coefficients of the whole body, and of the after body, and also upon the vertical prismatic coefficient of the whole body, $\frac{C_B}{C_{WL}}$. The latter seems to be a better quantity to use for plotting the wake values for single-screw vessels of full form.

If the meter wheels had been placed forward of the test position, I should expect the humps shown in the curves of Fig. 27 to occur at smaller values of $E \div H$.

The wake values for the above models were obtained by running the meter on the center line of the model and upon the left-hand side of the center line. The working platform is so located that this is the most convenient position. The wake values when off the center line would be different if measured by the same wheels upon the right-hand side of the models.

In the case of Model 5 the meter was run in certain cases upon the right-hand side as well as upon the left-hand side, and the results are given below.

Model 5, no bossing.

Wheels out 2 $\frac{9}{16}$ inches from center line.

Draught of model equals 7.07 inches.

Wheels up from the keel 2¾ inches.

	3¾″ diam.	4½″ diam.	5⅜″ diam.
Left side.....	18.3%	20.6%	22%
Right side.....	18.3%	21.7%	25%

Wheel up from keel, 3½ inches:

	3¾″ diam.
Left side.....	32.7%
Right side.....	29.3%

The meter wheels were right-handed screws which were placed on the meter shaft face forward. The water caused them to turn right-handed, *i. e.*, the top of the wheels turned to the right. When located on the left of the model they corresponded to in-turning screws, and when on the right-hand side of the model they correspond to out-turning screws.

When the meter wheel is on the left-hand side and one of the blades is extended vertically upward, its face slants forward and inward and is more nearly normal to the path of water following the water lines than when it is on the right-hand side and the blade surface slants forward and outward. In this latter position the surface is more nearly parallel to the adjacent surface of the ship.

When the wheel is on the left-hand side of the model and one of the blades is extended horizontally inward, the face slants downward and forward and is somewhat parallel to the buttock lines of the adjacent hull. When the wheel is on the right-hand side, the face of an inward extending blade is slanting forward and upward or at right angles to the buttock lines of the adjacent hull.

The tip of the 5⅜-inch wheel reaches over nearly to the center line of the model, and the larger wake which is recorded when on the right-hand side must be caused by a flow approximately parallel to the buttock lines. As the wheel tips clear the center line more and more, as is the case in the smaller sizes, the predominating effect is that of a flow parallel to the water lines, and the wheel on the left-hand side shows a greater wake.

When self-propelled models show different wake values for inward and outward turning screws it is not because there is an actual difference in the wake, but rather because there is a virtual change in the pitch of the propellers due to the direction of flow in the wake.

A study of the wake curve for Model 6 in Fig. 27 will show that wake values derived from the tests of center-line screws on self-propelled models of full form must be subject to considerable error. When tested in the "open" the water is fed to the screw with uniform velocity. The central portion of the screw does not contribute much to the thrust, due to the alteration in virtual pitch caused by the thick blade sections at the root. The slip angle is slight anyway, and there may even be a negative thrust over the inner part of the thick-bladed screws.

If the water were fed to the central portion at a slower rate than to the outer portion, the thrust would be increased and the efficiency of the screw improved. This is exactly what happens to a screw whose center is located in the region of maximum wake. Fig. 27 gives the variation in wake in a vertical plane passing through the center line of the model. In a horizontal plane passing through the center of the screw the wake is a maximum at the center line and decreases rather rapidly as one leaves the center line. Thus we may have in a full model such conditions of flow in the wake that the propeller may develop a greater efficiency than when tested in the "open."

In the case of Model 6 the benefit to be derived from lowering the propeller from an elevation of 0.4 the draught, an ordinary position, to an elevation of 0.2 the draught can be easily seen. We know from experience that great improvement follows such lowering of the propeller, and these results show that it is not due alone to placing the propeller where it will not react so strongly on the hull, but is due in part to improved efficiency of propeller.

As regards the extension of wake values obtained from models to full-sized ships, there is a division of opinion as to whether they ought to be increased or decreased. Eminent authorities claim that the wake is larger in models than in corresponding ships. This is hardly in accord with our treatment of surface friction in short and long planes.

In the case of surface friction it is assumed that the coefficient of friction for a short plane will be greater than for a long plane, due to the fact that the long plane is in contact with the water for a longer time and has a chance to give a greater forward velocity to the adjacent water. This causes the average rubbing velocity of the long plane to be less than for a short plane, and a smaller coefficient is used for the long plane.

The greater forward velocity of the adjacent water at the aft end of a long plane would mean a greater wake value for a long plane than for a short plane.

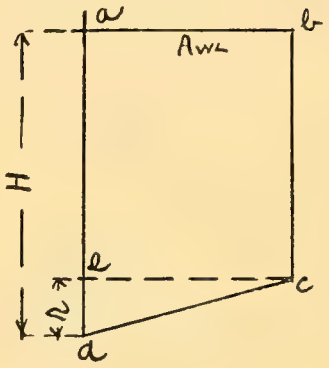
This study of the wake of models, while not extensive enough to be absolutely conclusive, would seem to warrant the statement that any complete system for determining wake values must take account of the following conditions:

1. The diameter of the screw relative to the draught of the ship.
2. The draught of the ship relative to the breadth of the ship.
3. The fore and aft position of the screw.
4. The transverse position of the screw.
5. The vertical position of the screw relative to the keel.
6. The vertical prismatic coefficient of the ship.

APPENDIX A.

Let the displacement of a ship be represented by a figure such as *a b c d*.

a b represents to scale the area of the loadwater line, *a d* equals the draught, and *r* is the virtual rise of floor.



$$A_{WL}\,(H-r) + A_{WL}\,\frac{r}{2} = \text{volume of displacement} = V,$$

from which,

$$r = 2\left(H - \frac{V}{A_{WL}}\right),$$

$$V = L \cdot B \cdot H \cdot C_B,$$

$$A_{WL} = L \cdot B \cdot C_{WL},$$

$$\therefore\ r = 2\,H\left(1 - \frac{C_B}{C_{WL}}\right).$$

$$\text{Vertical prismatic coefficient} = \frac{V}{A_{WL} \cdot H} = \frac{C_B}{C_{WL}}.$$

THE PRESIDENT:—We are now to have the pleasure of a paper, No. 6, entitled "Some Experiments on Propeller Position and Propulsive Efficiency," by Rear Admiral David W. Taylor, Honorary Vice-President.

Rear-Admiral Taylor, in presenting his paper, said: "Mr. President and gentlemen, my main object in presenting this paper is to attract the attention of the profession to a field which is large and unexplored, and the importance of exploring it. If I had known of the very comprehensive work that Professor Bragg had done, I do not think I would have undertaken to publish this paper."

Rear Admiral Taylor then presented the paper.

SOME EXPERIMENTS ON PROPELLER POSITION AND PROPULSIVE EFFICIENCY.

By Rear Admiral D. W. Taylor (C. C.), U. S. N., Honorary Vice-President.

[Read at the thirtieth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 8 and 9, 1922.]

After publication of results of years of Model Basin experimentation, the naval architect and marine engineer can now determine in advance with reasonable accuracy, for normal forms, the effective horse-power of a ship, and the dimensions and proportions of a propeller which would propel the ship with high efficiency if it were Froude's phantom ship, which has the resistance of the actual ship but is assumed not to disturb the water.

But we have to deal with actual ships, and the reactions between ship and propeller are very complicated phenomena. The wake of the ship of course affects the action of the propeller, and the suction of the propeller adds to the resistance of the ship. The thrust deduction is always positive, *i. e.*, the thrust is greater than the resistance of the ship without the propeller. Nearly always, however, the wake is also positive, which tends to increase the efficiency of propulsion. We generally and conveniently characterize the net results of the opposing factors as hull efficiency. If this is unity, the power required to propel the actual ship is the same as if it were Froude's phantom ship, while a hull efficiency greater than unity means that we can get along with less power and vice versa.

A brief enumeration of the factors affecting hull efficiency indicates the difficulties of dealing with it accurately. Considering the hull, it is affected by dimension and shape, but more particularly by the fullness and shape of the after body. A "V" stern, for instance, will show a somewhat different wake from a "U" stern, and the thrust deductions upon it will not be quite the same.

Considering the propeller alone, the hull efficiency must be somewhat dependent upon its dimensions and proportions, blade area, blade thickness, shape of blade, etc.

Considering the combination of ship and propellers, the hull efficiency must be affected by the number and locations of the propellers. For a single-screw ship, the propeller position may be varied vertically and longitudinally. For vessels of two or more screws, locations may be varied transversely for side screws.

For high-speed ships the hull efficiency must be affected by speed.

Probably of the many factors involved, those of location are most in need of systematic investigation because in many practical cases there is some choice of location and we would like to know whether we can gain anything by making a proper choice, and also whether we could gain by so shaping our designs as to permit a favorable location without counterbalancing loss in other respects.

The experiments which are the subject of this paper, recently made at the U. S. Model Basin, deal with the question of location for a single-screw low-speed vessel. They were initiated while I was chief constructor, and my successor, Chief Constructor Beuret, has kindly permitted their publication. The lines of the model used are shown in Fig. 1, Plate

37, and it will be observed that it is of rather a full type. It is hoped that at some future time if an opportunity permits, the stern lines may be further fined and the experiments repeated.

Fig. 2, Plate 38, shows the three model propellers used. With the possible exception of 571, they were smaller than would be used for the actual ship in practice. This permits a maximum vertical change of position and insures that the propellers work at a high real slip and cover a wide variation of slip. Fig. 3, Plate 39, supplemented by Table I, shows the test positions for the propellers, three positions at the upper level, three at the lower level, and three propellers used in each position. It was then necessary to make eighteen sets of runs at each speed of model. Figs. 4, 5, and 6, Plates 40, 41, and 42, show the usual characteristic curves of the three propellers as tested apart from the model. In making the tests with the propellers attached, the model was self-propelled at the desired speed, the torque and thrust being determined. From this there were deduced the two quantities w and t. The average speed of the wake over the propeller area is the speed of the ship multiplied by w, the wake fraction. The thrust deduction coefficient t is a quantity such that the actual thrust multiplied by the factor $(1 - t)$ is the resistance of the vessel without the propeller. The hull efficiency, as usual, is expressed by $1 - t/1 - w$.

Tests were made at a number of speeds extending from 2 knots speed of the model to 2.8 knots speed of the model, but the variations in the results with speed were not sufficiently marked with this model to be significant.

Fig. 7, Plate 43, shows the reduced results in the small tables, each located with its center in the same position relative to the ship (indicated by the stern outline) as the propeller centers. As is to be expected from a single set of experiments on such a small scale, there are some inconsistencies in the results. It would require other experiments enabling cross-fairing to eliminate them. Broadly speaking, however, Fig. 7, which is confirmed by the results at other speeds, shows that the dimensions and proportions of the screw had a minor effect upon the hull efficiency. The very wide variation of slip resulting from the variation in screw dimensions had comparatively little effect. At each level, as the screw was placed further and further aft, the wake fraction and thrust deduction coefficient fell off steadily. These changes rather neutralize one another, so that in this case it does not appear there was any material gain by variation in the fore and aft position of the propeller. When, however, we consider the vertical variation, it is another story. For the upper locations the hull efficiency is consistently higher than for the lower, the gains being somewhere between 15 and 20 per cent. This is in accordance with what might be expected from theoretical considerations.

It would seem that the naval architect is confronted by another case of conflicting tendencies where a compromise is necessary. For the majority of vessels virtually all considerations, except that of hull efficiency, dictate the lowest practicable position of the propeller. Doubtless in sea-going vessels with reciprocating engines the considerations dictating maximum submergence must preponderate, but for vessels with types of propelling machinery not subject to racing in heavy weather, and for vessels primarily for smooth-water service, we cannot ignore the fact that the higher the propeller location the greater the hull efficiency and hence possible efficiency of propulsion.

I say "possible" efficiency of propulsion because to take full advantage of the greater wake associated with high propeller locations, the high propeller should be of somewhat greater diameter than the low propeller for such a vessel as Model 2441.

In conclusion, I should like to record my appreciation of the assistance in the preparation of this paper given me by the Model Basin Staff, headed by Captain Eggert (C. C.),

U. S. N., in charge of the Model Basin. It was necessary to interfere with other important work to get in these experiments. I hope further experiments along this line, planned at the Model Basin, may appear in the Transactions of the Society in due time.

TABLE I.—PROPELLERS FOR MODEL 2441.

Models $\frac{1}{19.7}$ full size.

Propeller No.	570	569	571
Diameter	8.7″	9.7″	10.8″
Pitch	11.4″	9.2″	7.8″
Tips submerged, upper position	1.7″	1.2″	0.7″
Tips submerged, lower position	7.8″	7.3″	6.8″
Tips below keel, lower position.	1.3″	1.8″	2.4″

DISCUSSION.

THE PRESIDENT:—These two papers, No. 5, "A Study of the Wake of Certain Models by Means of a Current Meter," by Prof. E. M. Bragg, Member, and No. 6, "Some Experiments on Propeller Position and Propulsive Efficiency," by Rear Admiral David W. Taylor, are now open for discussion. They are two very important and very interesting papers, and I hope that we shall have a very interesting discussion of them.

PROFESSOR L. B. CHAPMAN, *Member:*—These two papers by Admiral Taylor and Prof. Bragg are very valuable contributions to our Transactions, and both gentlemen should receive our thanks for the information presented today.

Admiral Taylor in his characteristic fashion has stated his conclusions in a clear and concise manner, and his results will be very useful in determining the probable wake and hull efficiency.

Prof. Bragg has certainly given us a great deal of information, and he has covered such a wide field that it has been impossible to thoroughly study his results in the short time available.

When our knowledge of wake and the factors governing it has been carried a little further, propeller design will be much simpler and more certain than it is today.

Taylor's data on model propellers are held to be unreliable and of little value for design purposes in some quarters, but this is entirely due to the fact that they have been used without adequate knowledge of wake values. These two papers presented today give valuable information for estimating the wake, and that is why I consider the papers of such practical importance.

I have recently made a large number of comparisons between trials and calculated results from Taylor's $\delta \rho$ diagrams, and when the wake can be closely estimated the check has been very close indeed. The use of Taylor's charts is much simpler than any other method, and when proper wakes, thrust deductions and hull efficiencies are used the results are, to my mind, even more accurate. I should like very much at some future time to present a summary of this investigation before the Society.

Up to the present time our knowledge of wake has been from the investigations of Luke (presented before the Institution of Naval Architects in 1910, 1914, and 1917) and McEntee's investigations on self-propelled models.

The results of Prof. Bragg, especially for single-screw ships, appear to be in close agreement with the investigations mentioned above. It is almost impossible to make a careful comparison, for as yet it is very uncertain what the controlling factors are. Luke plotted his results on block coefficient, but Fig. 4 in Prof. Bragg's paper shows conclusively that block coefficient is not the most important controlling factor. Prof. Bragg's suggestions of using a vertical prismatic coefficient is very interesting, and this may be one of the influencing factors. I feel, however, that the longitudinal coefficient (prismatic) of the after body is one of the most important factors. Luke's and McEntee's investigations bear this out, and Prof. Bragg's model No. 1130 indicates the same thing.

I would like to ask Prof. Bragg if in his study of the results he attempted to plot any of the data on this basis.

The difference in the wake values between models No. 1130 and No. 1131 is very interesting and can hardly be charged up to the difference in beam-draught ratio. A comparison of these two models on the same block coefficients and percentage of run shows a variation in wake of about 20 per cent, which is hard to explain.

Prof. Bragg has carried his investigations into new fields and has given a great deal of additional information to that already existing.

Mr. William W. Smith, *Member:*—The data given in Prof. Bragg's paper are very valuable for estimating the wake fraction. However, for estimating propeller performance two other hull coefficients are required, viz., the hull efficiency and the rotative efficiency. It is hoped that in due time data for estimating these coefficients also will be added to the present valuable data.

In making propeller estimates it is the regular practice of some engineers to take the hull and rotative efficiencies as unity. It is evident, however, that such assumptions may introduce considerable errors in certain cases.

Referring to page 100, I wish to ask the following questions: (1) In passing from the model to the full size vessel, does the law of comparison with respect to size and speed hold exactly? (2) If not, what allowances should be made? (3) What, if any, data are available on this subject?

It also seems to me that the following elements require consideration in determining the hull coefficients of a vessel. These elements naturally divide themselves into three groups:

1. *Proportions and Form of After Body:*—Length, draught, beam, prismatic coefficient, center of gravity forward of the after perpendicular and above the base line.

2. *Size and Location of Propeller:*—Size; longitudinal, transverse, and vertical positions; and tip and axial clearances.

3. *Miscellaneous:*—Struts and bossings; cutting away of deadwood; rake of shafting and trim of vessel; location of rudder behind screw; speed-length ratio, etc.

In view of the large number of factors involved, it does not seem feasible to treat their application in elementary form. It would appear more practical to divide all vessels into six or eight main groups, preparing for each group suitable data and coefficients for taking care of practical variations.

On page 98 the author recommends the use of the vertical prismatic coefficient of the vessel as the basis for estimating the wake fraction. Mr. James Semple, in a paper read before the Institution of Naval Architects in 1919, used the prismatic coefficient of the after body for this purpose. As far as I can see, the forward and the parallel middle bodies will have no appreciable effect on the hull coefficients. It seems desirable therefore to consider only the after body. The prismatic coefficient of the after body alone will not be sufficient unless there is a standard relation between all of the elements given above. Otherwise it will be necessary to provide data to allow for such variations.

Referring to the tests at various draughts, it would be of value if the author would give the prismatic coefficient of the after body for each draught.

It would also be of interest to know how Prof. Bragg's data compare with those given by Mr. Luke in 1910 and 1917, and by Mr. Semple in 1919.

Referring to Plate 30, Fig. 4, it is noted that the block coefficients of these particular models have very little effect. This seems to indicate that block coefficient alone is not a very suitable basis, and that considerable errors can occur in certain cases if the other elements, as noted above, are not allowed for.

Referring to Plate 35, Fig. 23, it is noted that the wake curves for the wing positions do not agree with those for outward turning screws given by Luke in 1910. According to his curves, the wake increases with the diameter. For inward turning screws, Luke's curves agree with the author's.

The large wake caused by a thin board in front of the wheel, as shown in Plate 36, Fig. 27, is more than one would suppose. In this case the projected area of the board on the disc area of the wheel is one-quarter of the latter, and the wake is 20 per cent. This gives some idea of the considerable effect of struts, bossings, and deadwood in so far as they retard the flow into the wheel.

These tests show that the effect of the position of the wheel is very great. Therefore, in preparing propeller estimates, I believe that more consideration must be given to allowing for this feature.

The curves and data given in this and other papers, which cover wake and other hull coefficients, are very complex and, in fact, almost confusing. It would be most useful and desirable to reduce these data to some more simple and usable form for regular use in preparing estimates; in other words, to standard estimating data.

This paper also emphasizes the difficulty of making estimates accurately from general data, and the importance of self-propulsion tests which represent exactly the conditions to be met with. However, self-propelled model tests will not be truly valuable until they are proved to be reliable. This will not be until a number of test and trial results are compared, coordinated and published.

Prof. Bragg has thrown a great deal of light on a subject which greatly needed it. However, the present knowledge of this subject is by no means complete, and it is hoped that research work of this nature will continue. I am sure that the Society is very appreciative of Prof. Bragg's work.

Captain Joseph H. Linnard (C. C.), U. S. Navy, *Member of Council:*—Prof. Bragg in his paper describes the various methods for obtaining the various wake figures, and then he goes on to state how he gets the average value by the use of the current meter, which, in effect, is a propeller, and I will ask Prof. Bragg if he will state the manner in which the current meter averages the wake.

I also ask whether he has made experiments in comparison with the Pitot tube, to determine that average with equal areas, as would be determined in the case of the propeller averages; whether he averages the amount simply or whether there is any relation to energy or speed which would make the higher speeds count more heavily owing to their relatively greater energy in their effect on the current meter propeller than on the speeds that are lower, so that they would not average as the mere numerical sum, but more or less to the square of the wake speeds?

Professor Herbert C. Sadler, *Member of Council:*—I would like to relate a little experience that occurred some years ago when we first started work in the Experiment Tank at the University of Michigan. I made some models of some of the lake freighters, and worked out the effective horse-power and had an opportunity to check them up with the actual vessels.

I was surprised to find that the propulsive coefficient had to be something like 65 per cent or more in order to get the tank results to agree with the practical results. At that time it seemed to me that there must be something wrong somewhere, because we hardly expected large capacity freighters to have a coefficient of 65 per cent, such as you get in battleships.

Admiral Taylor's paper gives the answer. You will notice the hull efficiency is considerably over 100 per cent, and Commander McEntee showed the same thing a year or so ago. In the case of lake vessels, vessels with 19 feet draught and propellers 14 or 15 feet in diameter, we are reaching out into the top regions of the wake, much more so than in the case of the ocean liner where the draught is much greater, and the propeller no greater in diameter. I would like to thank Admiral Taylor personally for clearing up a matter which originally gave me considerable trouble.

Admiral Taylor suggests that the stern of the models tested should be made finer in future tests. I would also suggest that it be made fuller also so as to cover vessels of .75 coefficient.

Mr. William W. Smith, *Member:*—On page 103 Admiral Taylor states that the hull efficiency must be affected by speed. If Admiral Taylor could furnish data showing what this effect is, it would be of value.

I have sought reliable data for estimating the effect of speed on the performance of propellers but have found none which seem reliable except the charts given by Admiral Dyson. These data, however, are only applicable to his method of estimating propellers. It would also be very desirable to have similar data for estimating full size propellers from model experiments.

Referring to Plate 43, it is noted that the author does not give the rotative efficiency. It would be of value if Admiral Taylor would define the method of referring the "behind" to the "open" tests.

Referring to Plates 40 to 42, it is my understanding that the C_t value from the "behind"

test is used as the basis for determining the nominal slip ratio. For a single-screw vessel such as this, I believe the C_q value from the "behind" test is usually from 3 to 6 per cent higher than C_q value corresponding to the nominal slip determined as above.

The rotative efficiencies for the tests which were described by Commander McEntee in the paper which he read before this Society in 1919 were from 94 to 96 per cent.

From Plate 43 it appears that the axial position of the propeller has practically no effect on the hull efficiency. Mr. James Semple described a similar test in a paper read before the Institution of Naval Architects in 1919. The curves which he gave in Plate 51 of his article shows that the hull efficiency increases somewhat as the propeller is moved away from the stern post. It is my understanding, also, that the propulsive efficiency falls off if the propeller is moved towards the stern post, and especially if it is a large one.

The large increase in hull efficiency due to raising the propeller is extraordinary. The gain in efficiency varies from 8 to 32 per cent, the average being 16 per cent.

On pages 104 and 105 the author indicates that a high location of propeller is desirable because of the improved efficiency. This is contrary to the general idea that the lowest position is the most efficient. Admiral Dyson gives an example in his book where lowering the propeller improved the efficiency greatly. Prof. Bragg also calls attention to this feature on page 100.

To investigate this matter fully, estimates were prepared for a small vessel having a form of after body exactly similar to that given in Plate 37. The following cases were used:

Case 1. Given the speed of vessel and R. P. M. $V = 8.75$, $H_a = 376$, $R = 135$, $D = 10$.

Case 2. Given the S. H. P. and R. P. M. $P_s = 810$, $R = 135$, $D = 10$.

Case 3. Given the wheel and R. P. M. $D = 10$, $P = 8.29$, $R = 135$.

A comparative summary of these estimates is given in Table 1, page 110, from which it is seen that the higher propulsive efficiency is obtained in the lower position for cases 1 and 2. This result is due to the higher slip ratio which occurs when the wheel is in the higher position. The higher slip ratio of course gives a lower propeller efficiency. Also the pitch for the higher position must be lower, which augments this effect.

Case 3 is not a very practical one, but is given as a matter of interest.

The vessel referred to above is a small freighter driven by a Diesel engine.

I hope that papers describing tests and experiments at the Washington tank will be read at each meeting of the Society. I might suggest that the effect of trim on self-propulsion be investigated. It is often stated that trim by the stern greatly improves the driving qualities and increases the speed for a given vessel.

It would also be valuable to investigate the effect of rake of the shafting.

Admiral Taylor has added another to the many valuable papers which he has contributed on this subject. The Society, and especially the shipbuilders, are much indebted to him for these valuable contributions.

PROFESSOR BRAGG:—First, I would like to make a few remarks about Admiral Taylor's paper. I am wondering whether he has a record of the shaft horse-powers which it actually took to run these models under the different conditions, at one or more speeds. In 1911 Prof. Peabody reported to this Society some results which he had obtained from tests of the Froude. He gave both the hull efficiencies and the shaft horse-powers which it took to drive the boat at certain speeds. The Froude had a thick stern post and the propeller was placed anywhere from 1 to 30 inches back of it.

TABLE 1.—*Comparison of Propulsive Efficiencies for High and Low Positions.*

Position		Low	High
h		.94	1.12
w		.22	.43
	Case 1		
P		8.94	8.4
S_e		.48	.61
S_a		.226	.218
P_s		810	856
E_o		.538	.426
E_s		.464	.439
	Case 2		
V		8.75	8.67
H_a		376	366
P		8.94	8.25
S_e		.48	.602
S_a		.266	.212
E_o		.538	.438
E_s		.464	.452
	Case 3		
V		8.30	8.70
H_a		322	370
S_e		.463	.588
S_a		.249	.213
P_s		710	818
E_o		.525	.440
E_s		.454	.452

TABLE 2.—*Symbols.*

h = hull efficiency.
w = wake fraction.
P = pitch in feet.
S_e = effective slip ratio as defined by Froude.
S_a = apparent slip ratio.
P_s = shaft horse-power.
E_o = propeller efficiency in open water.
E_s = propulsive efficiency of vessel = H_a/P_s
V = speed of vessel, knots.
H_a = effective horse-power with appendages under standard test conditions.
R = revolutions per minute.
D = diameter in feet.

The propulsive coefficient at 5 knots was increased by 52 per cent when the propeller went back from the 1-inch position to the 6-inch position, and yet the shaft horse-power was only 9 per cent less; for a 52 per cent variation in the hull efficiency there was only a 9 per cent variation in the power. At 6 knots a 35 per cent variation in the hull efficiency was accompanied by only a 9.5 per cent variation in the power. In going from the 6-inch position to the 30-inch position, the hull efficiency decreased about 10 per cent, but the shaft horse-power increased only about 3 per cent.

I think that we need a little more light on the extent to which the wake fraction should enter into our expression for hull efficiency; i. e., whether it should be used to its full value or not.

Also, referring to the question of the efficiency of the propeller in a disturbed stream, I notice that back in 1920, Prof. Abell, in the *Engineer* for September 24, wrote an article about some investigations which he made upon a propeller in a disturbed stream. He assumed a somewhat simple disturbance, but even so, he found from a purely theoretical consideration that the efficiency curve of a propeller in such a disturbed stream was somewhat different from the efficiency curve in the "open" condition.

Perhaps some might ask just how these results of mine check up with those of Admiral Taylor, and I may say that I could not compare them very easily, because his propellers were tested at heights above the keel which corresponded to elevations of .2 and .6, while most of my results were grouped around an elevation of .4; so that it would require quite a bit of averaging in order to compare them.

The fore and aft position which I used for my meter wheels was almost exactly halfway between position 2 and position 3 in his paper, considering position 1 as nearest the stern post and position 3 as the aftermost position. As far as I could compare them, they seemed to check in rather well.

Now, replying to some of the questions on my own paper, first allow me to thank all of the gentlemen who have spoken so kindly of the results here given.

I find that I have not stated anywhere in the paper just what I mean by the term "wake." Since there are two definitions of this term, it may be well for me to state that I have used it in the sense that it is ordinarily used upon this side of the Atlantic, i. e., as the ratio of the speed of the following water to the speed of the ship.

No attempt was made to explore the entire wake prism of the models but only that portion in which propellers ordinarily work. The wake prism varies in extent, dependent upon the fullness of the model. In the case of the fullest model, No. 6, the meter was carried below the surface a distance equal to the breadth of the model, and an appreciable wake of 2.5 per cent was registered. The meter was also carried out to one side a distance from the center line equal to the breadth of the model, and a wake of 1.5 per cent was registered.

In the case of the 10-foot plane, however, the wake did not appear to extend below the bottom of the plane, as the wake became zero when the center of the meter wheel was below the bottom of the plane a distance equal to the radius of the meter wheel.

A search of the wake prism in the fore and aft direction would probably reveal marked irregularities, as we would find different combinations of frictional wake, stream-line wake, and wave motion. In one case the meter protruded through the forward propeller post of a double-ended ferry, thus bringing the meter wheel into the position occupied by the forward propeller. In this case, a model which had a wake at the stern of about 33 per cent had a wake at the bow of 23 per cent. The meter wheel would probably have shown widely differ-

ing wake values between these two positions dependent upon the location of the wheel relative to the wave crest or wave hollow.

A change in speed will cause some difference in the location of wave crests along the length of the model, and this probably accounts for the fact that in fine models the wake values usually fall off with increase in speed above the normal, while in full models there is a rapid increase in the wake value as the speed is approached where a hump appears upon the resistance curve.

If I may be allowed to emphasize certain points which I have made in the paper, it may answer some of the questions which have been asked. I have tried to bring out the variation in wake which accompanies variation in draught. The wake decreases quite rapidly as the propeller is placed nearer the keel, with a fixed draught; and decreases less rapidly as the draught is increased with the propeller at a fixed height above the keel. One of the consequences of this is that the increase in *apparent* slip which is usually noticed as a ship is loaded down to a deeper draught may not indicate any material increase in the *true* slip.

Another point which I have tried to bring out is the effect of fullness of form upon wake. Fig. 26 shows that the relation of wake to form fullness cannot be represented by a straight line, but is a curve which becomes very steep in the region of the full forms if plotted upon a longitudinal coefficient, and less steep if plotted upon a vertical coefficient. In Luke's 1910 paper, Fig. 1 shows a number of wake values obtained from models with a block coefficient of less than .70. A straight line can be used here to represent fairly closely the variation of wake with fullness of form, but this same line cannot be used for the wake of fuller models. Furthermore, the ratios of breadth of ship to draught, of diameter of propeller to draught, and of elevation of propeller to draught should be known, and it would be found, probably, that a series of lines or curves would have to be used to give the relation between wake and fulness of form.

Fig. 27 shows that the wake is very turbulent with full forms and raises the question as to the accuracy of the wake values derived from self-propelled models upon the assumption that the efficiency of the propeller is the same in the "behind" condition as in the "open" condition.

No general statement can be made regarding the effect of bossing upon the wake, as this effect varies with the diameter and immersion of the wheel. If we can set up some system which will give the wake on the center line fairly accurately, I believe that the wake off the center line, both in the naked and bossed condition, can be expressed as a percentage of the center-line wake.

As pointed out in the body of the paper, the wake values off the center line were obtained with in-turning wheels, so that the results would be expected to check more nearly with those obtained from in-turning propellers.

The curve for the wake of the 10-foot plane in Fig. 27 seems to differ in character from those obtained for the models. This is due to the fact that the flow around the plane is probably two-dimensional in character, while that around the models is three-dimensional.

A study of Fig. 27 will lead to the conclusion that the curves in Fig. 26 may be considerably modified for full models as the wheel diameter is reduced. A cross-section of the curves in Fig. 27 for a wheel elevation of .4 would show the wake for model 6 to be less than the wakes for models 3 or 5, when the diameter of the wheel is 3¾ inches instead of from 5 to 6 inches as in Table IV.

Prof. Chapman and Mr. Smith refer to the prismatic coefficient of the after body as a

desirable quantity for correlating wake values. I am of the opinion that this investigation shows very clearly that this quantity is not at all desirable for this purpose. Fig. 4 shows the variation of wake with block coefficient. The curves are beginning to turn up fairly rapidly at the larger values of block coefficient, and if the experiments had extended to as full models as in Fig. 2, the variation in wake from the finest to the fullest model would have been considerable. In this series of models the after body was unchanged; the fore body alone was changed. Consequently this considerable range of wake values would have to be plotted upon one value, 0.724, if the longitudinal prismatic coefficient of the after body alone were used as abscissa.

The longitudinal prismatic coefficient of the whole body is much to be preferred to the coefficient of the after body alone. There is nothing in Fig. 26 to show that the latter has any advantage over the former, while Fig. 4 shows that the after body coefficient has in certain cases very serious disadvantages.

I have added to Table I the prismatic coefficients of the after body, as requested, but I consider that the experiments upon models 1130 and 1131 show most decidedly that this quantity is not desirable for plotting purposes.

Prof. Chapman states that the difference in wake values between models of the same block coefficient in Figs. 2 and 4 is hard to explain on the basis of difference in breadth-draught ratio and vertical prismatic coefficient. On the contrary, I think a study of the curves will show that it can be explained very easily. In presenting the paper to you a while ago I tried to lay especial emphasis upon the rapid decrease in wake value as the draught increases, especially with small wheels on the center line of the model. In the case of model 1130, in Fig. 2, the wake shown for a block coefficient of .73 with a 3¼-inch wheel at 6.75-inch draught is about 27 per cent. In the case of model 1131 under the same conditions, the wake is about 41.5 per cent, a difference of 14.5 per cent.

Model 1130 has a breadth-draught ratio of 2.26, while model 1131 has a breadth-draft ratio of 2.44. Model 2 has a somewhat finer block coefficient than .73, and for about this difference in breadth-draught ratio Fig. 11 shows a difference of wake of about 8 per cent.

Model 1130 has a vertical prismatic coefficient of .851, and model 1131 has a vertical prismatic coefficient of .883. The increase in wake in going from one of these values to the other in Fig. 26 is nearly 4 per cent, and with a smaller meter wheel than those used in obtaining the results given in Fig. 26 would probably be more than 4 per cent. This difference in breadth-draught ratio and vertical prismatic coefficient easily accounts for the difference shown in Figs. 2 and 4.

In comparing the results given in this paper with those given elsewhere, it should be borne in mind that all comparisons should be on the basis of similarity in ratios of draught to breadth, diameter of propeller to draught, elevation of propeller above keel to draught, and in fullness of form. The data published heretofore have not been sufficiently complete to enable all these conditions to be determined. As an instance of this, tables are given in the appendix of Luke's 1910 paper showing the particulars of forms of models experimented upon by R. E. Froude, Signor Pecoro, and Messrs. John Brown & Co. The data given are sufficient to determine the prismatic coefficient and the breadth-draught ratio only, and this latter varies from 2.38 to 5.25 in the different models. The variation in other particulars is probably as great, and unless the other data are available it will be impossible to get consistent results from this data.

I should like to point out to Mr. Smith that the wake produced by the 10-foot plane is

hardly an indication of the wake produced by struts, since the surface of the plane is very much greater, relatively, than would be the surface of the struts.

In reply to Captain Linnard I would say that I have made no experiments to determine how the wake given by a current meter wheel compares with the integrated wake of filaments as given by a Pitot tube. I should say, however, that it is a question of velocities rather than energy, as the meter wheel has ball bearings and can absorb very little of the energy of the stream.

Rear Admiral David W. Taylor:—There is very little I can add to what Prof. Bragg has said in the discussion, but there are one or two points I would like to mention. In the first place, as regards agreement between Prof. Bragg's paper and mine, as far as I can make out there is no disagreement. The wake is liable to vary so much with comparatively small changes of the model that apparently it is difficult to make any exact comparison, but as far as I can judge there is certainly no material disagreement. It might seem at first sight that there is some conflict. I found comparatively small, almost negligible variation of the wake with diameter of the propeller. Prof. Bragg found material differences with variation of diameter of his current meters. But his diameter variations were very large, while mine were not large, being less than 25 per cent.

There was another matter touched on, and that is the question of using a current meter instead of the actual propeller of the ship.

As regards the determination of the wake, the results should be the same if diameters are the same. If you take the model of the actual propeller of the ship and drive it idle in its proper place, developing no thrust, I do not see but what you must get the same results as Prof. Bragg with his current meter, which has practically no thrust. Then when you speed up the actual propeller and drive the ship the additional disturbance should not materially affect the wake. With the use of the current meter, Prof. Bragg can accomplish what would take a long time, using the propeller alone, but his method is of no advantage in getting information as to the thrust deduction, which is an important factor, and which is liable to alter conclusions drawn from the wake alone.

I would be glad to add information as to the power used, referred to by Prof. Bragg, but, as indicated in the paper, with the possible exception of propeller 571, the propellers were smaller than would be used in practice. This resulted in getting much less variation in propulsive efficiency than if the propellers themselves had been varied. That is also the reason why Mr. Smith's cases showed no gain. His low propellers were so small they were already working at excessive slip and when raised the slip had to go up to an impossible figure.

On the question of trim by the stern, we all have heard of it and discussed it for a good many years. Once I took it up in the Naval Institute and published an analysis of a number of trials of naval vessels, and that seemed to indicate, so far as the data went, that nothing would be gained by "trim" by the stern, as regards speed.

Our model basin results have shown for years that, as to trim by the stern or by the head, in practice for ordinary models there is no material effect on the effective horse-power, so that any effect of change of trim on the actual ship must be due to its effect upon the efficiency of propulsion—not the resistance of the ship.

As regards the method of determination of wake factor and thrust deduction, the propeller was tested in the open and then tested driving the ship. In driving the ship it showed certain revolutions and certain torques and thrusts. They correspond, in open water

work, to certain speeds of advance, and these speeds of advance were assumed to be the speeds of advance through the water behind the ship, from which the wake factor was readily determined. When torque and thrust coefficients gave slightly different speeds of advance they were averaged.

In pointing out the effect of the immersion of the wheel, I rather hoped to start something more in the way of discussion than we have had. It is rather a new point, and I was glad that Prof. Sadler was able to sustain my somewhat radical position on that matter.

We have had a good deal of discussion as to the basis of the formulae. Luke, as you know, who was the pioneer in this matter, and also Mr. Semple, who was also a pioneer, at first adopted the block coefficient, and Mr. Semple, two or three years ago, adopted the coefficient of the after body. I do not believe there is any single coefficient that can be used to advantage to cover the whole range for this reason: When you consider what the wake is, you find that it is really made up of three components. In the first place there is a frictional wake produced by the frictional drag upon the vessel. That is fixed and does not vary very much with fullness any more than surface varies with fullness. Prof. Bragg's experiments, with a 10-foot plane, confirm our *à priori* conclusions that it is an important factor. He got 20 per cent behind the 10-foot flat plane. Then we have the stream-line wake, due to the natural stream-line action around the ship, which means a forward velocity abreast the stern. That stream-line wake depends on the whole body of the ship, without any question, but, broadly speaking, the most important factor entering into it, it seems, is the fullness of the after water lines—that is the most important of the numerous factors entering into it.

I agree with Prof. Sadler that the way to modify the stream lines is not to modify the coefficients, but modify the after lines. That was our intention, and the idea was, without making much general change in the body, to find the after body or rather the after part of the after body.

The second component is very difficult to reduce to rule, but it seems to me that perhaps the block coefficient was inadequate. The vertical coefficient for the after body and the longitudinal coefficient of the after body upon which Semple plots his results would, I think, both be better guides. In view of the great influence of propeller position it is hardly worth while to strive for minute accuracy in determining the influence of the shape of hull.

We have another factor due to the stern wave. That is a factor affected by speed. There is no question about that, as we all know. In destroyers we sometimes have a negative wake, and the reason is that the stern is in the hollow of the wave which they have created. That wake depends upon the speed-length ratio and is a varying factor, which is liable to confuse the case for high-speed vessels. That is why I speak of the effect of speed. In all the cases we have discussed I presume the speed was low. It was certainly so in the case we tried, where the maximum corresponded only to about 12 knots on the large vessel. When we see the peculiar and material variations in wake brought about by comparatively small vertical or horizontal changes in propeller position, it looks to me as if it would be rather difficult, with our present knowledge, to reduce the matter to rule. Pending this it looks as if the best course is to actually test for wake by model experiment using a current meter, if you are looking for the wake alone, or a model propeller, if you are attempting to determine the wake and the thrust production.

Professor Bragg in the discussion desired further information as to the variation of efficiency of propulsion with hull efficiency. He is quite right in his inference that the efficiency of propulsion shown in the experiments did not vary as the hull efficiency, and though the

matter was covered to some extent in the original paper and the discussion, it is one of such serious practical importance as to seem to warrant further remark.

Even the largest of the three model propellers was too small to give a good efficiency in any position. I give in the table below its estimated actual slip and the corresponding efficiency of propulsion together with the wakes, etc., already given.

DATA ESTIMATED FOR FULL-SIZED SHIP WITH PROPELLER AS PER MODEL 571.

Propeller tip below surface.....	134″	134″	134″	13.8″	13.8″	13.8″
Propeller center abaft stern post..	11.58′	6.66′	2.15′	11.58′	6.66′	2.15′
Ship speed, knots	11.57	11.57	11.57	11.57	11.57	11.57
Wake speed	1.74	2.43	2.55	3.82	4.40	4.97
Speed of advance	9.83	9.14	9.02	7.75	7.17	6.60
Wake fraction	.15	.21	.22	.33	.38	.43
Thrust deduction.....	.19	.26	.27	.21	.30	.37
Hull efficiency	.96	.94	.94	1.17	1.12	1.12
Apparent slip	.09	.08	.09	.01	.01	.01
Actual slip	.23	.28	.29	.33	.39	.44
Efficiency of propulsion	.64	.60	.58	.70	.65	.60

The efficiency of propulsion is not $\frac{\text{E.H.P.}}{\text{I.H.P.}}$ but $\frac{\text{E.H.P.}}{P}$ where P is propeller power.

It is seen that, though there is a gain of something like 20 per cent of hull efficiency in the higher position, the gain of propulsive efficiency is 4 to 10 per cent only, and similar tables for the smaller propellers would show an actual loss in some cases. The reason seems fairly obvious. In the lower position the speed of advance of the propeller through the water in which it acts is 9.02 to 9.83 knots. In the upper position it is 6.60 to 7.75 knots. Now the propeller, if it were sentient, would know nothing about hull efficiency. It would know only that it was absorbing a certain power at a certain revolution and advancing *through the water in which it operates* at a certain average speed. This speed of advance is a vital factor in the case, and the propeller efficiency depends largely upon how well its design suits the speed of advance.

In the case above, propeller No. 571 from open-water experiments has a maximum efficiency of 65 per cent at a slip of 17 per cent figured on nominal or face pitch. In the low position, however, it is not working anywhere near its maximum efficiency, the slip averaging some 27 per cent corresponding to an efficiency of 62½ per cent. In the high position, in order that the propeller with a speed of advance of 6.60 to 7.75 knots may drive the ship at 11.57 knots, the slip has to go up to an average of 39 per cent with a reduction of propeller efficiency to 56 per cent or some 10 per cent less than the efficiency in the low position. No wonder, then, that the gain of hull efficiency of some 20 per cent is associated with a gain in propulsive efficiency of only 10 per cent at most.

The question at once arises: Is this condition unavoidable? The answer is certainly not, provided the design is properly made in the first place. In the model experiments

(which were not very complete) the same propeller was used in the high place as in the low place. There are two methods of avoiding the loss of propeller efficiency pointed out above.

Holding revolutions constant by increasing diameter and reducing nominal pitch, the slip per cent would be reduced and efficiency increased until we reach a balance between the rate of gain due to slip reduction and the rate of loss due to pitch reduction. This would show a substantial gain even in the extreme case above. But the fundamental trouble in the above case as regards propulsive efficiency is the high revolutions. The propellers, which as pointed out in the paper were smaller than would be used in practice, were all derived from assumed revolutions of 108 per minute for the full-sized propeller. While this is satisfactory for the purpose of investigating wake factor and thrust deduction, it is incompatible with a high efficiency of propulsion for the power to be absorbed and the speed of advance, particularly the latter.

When preparing a design, every factor present except propeller efficiency tempts the engineer to increase the revolutions of his propeller, and this has resulted in many unnecessarily inefficient ships.

I believe the copious experimental data published of late years have to some extent misled the designers because they have not covered the whole field.

Take the case above. The maximum efficiency of the propeller is .65 at 17 per cent true slip. The nominal slip based upon the speed of the ship is 11.57 knots is about .09 per cent in the low position. Without reliable data as to wake, etc., the designer who, as a result of published model data, can estimate very closely the maximum efficiency and corresponding slip of his propeller would be tempted to say the nominal slip of .09 allowing something for wake is near enough the slip of maximum efficiency for practical purposes and let the revolutions remain high.

If he had available, in the early stages of the design, however, reliable estimates of wake, it is not at all likely that he would pass an actual slip of 39 per cent corresponding to the high position, or anything approaching it in a lower position. Certainly before accepting such a high actual slip he would give a good deal of thought to the possibility of reducing his revolutions.

THE PRESIDENT:—These are two extremely interesting and valuable papers, and the discussions and the replies to the discussions have brought out additional information, and I am sure that I am only carrying out your wishes in extending the thanks of the Society both to Prof. Bragg and Rear Admiral Taylor for presenting these papers.

That completes the program for the afternoon. The meeting now stands adjourned until ten o'clock tomorrow morning.

THIRD SESSION.

THURSDAY MORNING, NOVEMBER 9, 1922.

President McFarland called the meeting to order at 10.15 o'clock.

THE PRESIDENT:—The first paper on the program this morning is one entitled "Efficiency in the Operation of Steamships," by Captain Daniel A. J. Sullivan, Member. Will Captain Sullivan kindly step forward to the platform and present the paper?

CAPTAIN SULLIVAN:—Mr. President and gentlemen, I would like to remark that since the writing of this paper, July 1, several conditions have changed in the ship and shipping business. One must be constantly alert to keep up to date with the developments of affairs in the shipping business, and when I sailed for European waters on August 14 I could have made several corrections in this paper; when I returned, just a few days ago, I could still make a few additional corrections, and the Secretary has informed me that I have the privilege of making these corrections in the finished paper, before its printing, which I hope to do.

It is rather difficult for one who is afloat to produce a paper of sufficient interest to you gentlemen, but I will try to do so.

Captain Sullivan then presented the paper, and during its presentation made these additional comments:

"The data of operation were taken from the records of over fifty vessels. It was sorted out, and finally the records of a number of voyages, complete from the commencing to load until the cargo was taken out of the ship, are given here, and the records of each individual item of expense were added together and the total shown in the paper arrived at. There are examples embracing the ships of three different companies, and I have promised faithfully that no name of any company or ship would be revealed.

"It is interesting to note that the fuel consumption of these three different ships is very close; and since the writing of this paper, fuel has increased greatly in price. On one of the voyages of my vessel, fuel was $1.05 and upward, and today we are paying $1.61.

"Those in the service know of the various items where the ship paid for part, and in some cases, for all.

"Of the total expense of handling the cargo and the total expense of the vessel, wages afloat, which has been the bone of contention, vary from 11.21 to 14.41; insurance varies from 18.1 to 12.1; wharfage from 1.9 to 1.7; and then there are contingency and brokerage fees and the usual fees for obtaining cargo and handling the vessels, grain fittings, and whether the ship is fitted completely to handle the grain, or partly fitted to handle grain. Subsequently, I desire to bring that point out to a greater degree and attempt to interest you in providing these special fittings.

"Supplies for the crew—that is, subsistence—vary from 1.4, which I will admit was a very hungry vessel, to 3 per cent.

"Under 'Miscellaneous' I have eliminated everything which varies over a small amount, which would only be cluttering up the paper, to averaging the various sundries, so that the mis-

cellaneous items are put in approximately as only 3 per cent, and these items in any ship would show only a small variation.

"On my ship, for the past two years, my subsistence account has not exceeded 52 cents per man per day, and we have what is known as a good ship. On our last voyage it was 43 cents."

In connection with the items of expense shown in the paper, Captain Sullivan said:

"In the last year my vessel is approximately 20 per cent under these amounts, and our repair bills are negligible. The last three-months voyage caused an expense in the way of repair bills of $208."

EFFICIENCY IN THE OPERATION OF STEAMSHIPS.

By Captain Daniel A. J. Sullivan, Member.

[Read at the thirtieth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 8 and 9, 1922.]

Since the inception of transporting freight by means of water routes until the present time, there has been one important question which has caused more worry and deep study than any other, and that is the cost of operation. In the study of this subject one is impressed with the importance of every detail which added together makes the whole, so that in delving into the records of the past, those of us who are now striving to produce efficiency realize the necessity that each and every member of the profession should understand that his efforts and his labor are a part of the whole, and if the results of his labor are not up to the mark, then the whole will be handicapped by just that amount. So in the efficient operation of any ship, every person who has had a part in designing, in building and then in operating that ship is responsible for his part, and if each and every one has produced perfect results then the result as a whole should be perfect.

In theory this is true, but in practice we find too many "exceptional conditions," which expression has been used to cover a multitude of blunders in the past as well as in the present. So in the study of this subject we must admit to ourselves that each of us is responsible for the results attained, and that on the blunders of the past we can erect a perfect organization for successful operation.

The history of shipping reveals many interesting events, and without spending too much time on the past, it is well to recall that supremacy of the seas has gradually changed from nation to nation since the beginning of water transportation until the present, and will continue to be fought out on economic lines until the end of time. In studying the cause of the gain or loss of the supremacy of the seas, it appears to be true that the nation which can build ships for less than others, and whose vessels can transport cargoes faster and cheaper than others, will rule the sea. Here again enters the "exceptional condition" in the form of government ownership and of government subsidy.

At the time of writing this article, there is an effort being made to place the merchant marine of the United States on an equal competitive basis with the merchant marine of other nations by the adoption of a ship subsidy. Those interested in the success of vessels under the American flag realize the necessity of this measure.

First, on account of the higher first cost of the vessels built in the United States.

Second, the American merchant marine is the only important American industry not protected by tariff.

Third, to equalize the present unfair competition on account of the subsidy paid to the merchant marine by other nations in competition with the merchant marine of the United States.

Fourth, on account of protection to other industries the standard of living of its employees is raised to a much higher level than the standard of living in any other country,

and it is unfair to the seafaring profession to force them to a standard of living which would not be tolerated ashore.

Many critics of American shipping insist that Americans cannot operate ships. These gentlemen forget the records of the past, the most interesting of which is the era of the clipper ship, which era commences prior to the War of the Revolution and continues until just after the Civil War, when the era of steam vessels begins. The years between 1843 to 1869 are to all Americans who love the sea the most interesting, as during this time American shipbuilders constructed the finest models of sailing ships ever launched. With these ships the American shipmaster proved himself superior to any shipmaster in the world, and it is a matter of record how American clippers were loading in China ports at higher freight rates while vessels of other nations could not get cargoes in the same port at lower freight rates, owing to the difference of speed, and here it may be well to quote from "The Clipper Ship Era," by Capt. Arthur H. Clark, published in 1910.

"Of the men who commanded the American clipper ships, it may be said that they carried the ensign of the United States to every quarter of the globe, with honor to their country and themselves. Each had his strongly marked individual traits of character and his human weaknesses. Nothing could be more remote from the truth than to imagine these men as blustering bullies at sea or rollicking shellbacks on shore; neither were they Chesterfields or Carpet Knights, afloat or ashore, nor at all the type of skipper that one is apt to meet in works of fiction. Many of them might easily have been mistaken for prosperous merchants or professional men, until a more intimate acquaintance disclosed the aura of salted winds and surging seas, and a world wide knowledge of men and cities. It may well be doubted whether braver, true-hearted gentlemen or finer seamen than many of the American clipper ship captains of half a century ago have ever sailed the seas."

When these men won the supremacy of merchant shipping for American vessels it was said of them in 1860 by a critic of the merchant marine of another nation: "We have no masters who can match the masters of American vessels, and until we do, and allow them full control of our vessels, we cannot compete successfully."

Even in those early days it was thoroughly understood that the success or failure of the venture was solely in the hands of the master.

Succeeding the era of clipper ships is the era of steam, and as other nations built and operated steamships the American ensign gradually faded from the sea, and the year 1913 saw American shipping at its lowest mark.

The World War commenced in 1914 and naturally the demand for tonnage grew, and as the demand increased the rates soared. Since everything connected with the shipping interest follows closely the law of supply and demand, the operating cost during the war period attained such heights as to be unbelievable. During this period of inflated prices, as a defensive measure, America had constructed a large number of vessels, and when peace was declared America found herself in possession of one of the greatest merchant fleets the world had ever dreamed of. It then became a problem how to make the best use of this fleet.

It is useless to attempt to conceal the fact that at this time there existed many steamship companies, whose organizers and officials knew little about the shipping business and less about the traditions and established customs of the sea. Wages soared, conditions afloat

and ashore became impossible, operating costs were excessive, claims for cargo damage and loss were unreasonably high, and with the perfection of systems of communication the status of the master and officers was reduced to practically that of a high priced office boy—obeying orders issued from ashore by those who were intoxicated by high freight rates and large profits, who thought more of the American dollar than they did of the safety of the vessel or its mark. However, as freight rates decreased, it was realized that steamship companies founded on inexperience could not endure, and it is to the credit of the profession to say that ability, experience, and efficiency are being recognized and will eventually regain control.

During the past two years, rates have fallen to the level of, and in some instances to a point lower than pre-war rates, and in the struggle of American vessels for existence in the shipping world against the better competition of foreign vessels which enjoy a lower operating cost, as well as a government subsidy, American shipping has reached that stage where the cost of efficient operation means success or failure to our merchant marine as a whole.

It is a fact that, amongst the various grades of ship officers, the American merchant marine can boast of having many who are efficient, but unfortunately many masters lack sufficient business training, due to the modern method in steamship offices where the master is not allowed to handle details with which he should be familiar, and naturally in this connection the shipowner is standing in his own light.

To establish a basis of comparison of the cost of operation for all classes of ships is an impossibility, and after considering the mass of data available it was decided that each vessel was an individual study.

Herewith are presented data of three vessels in transatlantic trade, reduced to an average of one voyage and all expenses are included; total cost represented as 100 per cent.

	Example A *Per cent*	*Example B* *Per cent*	*Example C* *Per cent*
Fuel	23.6	29.9	27.9
Stevedoring, tally, watching, clerks	20.6	16.0	22.9
Wages on ship	11.2	14.4	13.0
Insurance	10.4	8.1	12.0
Wharfage	7.7	1.9	2.2
Agency and brokerage	4.9	3.4	2.7
Grain fittings	3.1	2.9	...
Food for crew	3.0	3.0	1.4
Stores deck department	2.0	2.9	2.9
Stores engine department	2.5	3.4	3.6
Stores steward department	0.2	0.3	0.25
Advertising	2.4	0.4	0.3
Towboats	1.8	1.5	1.4
Pilotage	1.3	1.3	1.4
Port charges	1.4	1.8	1.6
Repairs	1.6	5.1	3.6
Miscellaneous	2.1	3.5	2.6
Laundry	0.2	0.2	0.25
Total	100	100	100

From a study of this data one readily sees that fuel, cost of handling cargo, wages and insurance are the most important items of expense.

Fuel is the most important item of expense in operation and is a subject to which little intelligent study has been given, and while general results have been compared, very little satisfactory data are obtainable. The U. S. Shipping Board has just appointed a committee to study this subject; this committee is afforded a great opportunity to render service to the profession.

The prevailing practice today is to buy fuel on a price basis, and no consideration is given to the heat units contained therein nor to the subsequent results obtained.

In vessels using oil fuel, where this fuel is carried in double bottoms, sufficient attention has not been given to the arrangements for heating the fuel in the tanks, with the result that in cold weather considerable loss occurs. However, many interested in efficiency feel that the Shipping Board Fuel Committee will submit data and promulgate a set of rules of procedure which, if followed, will greatly improve results.

Next in importance to fuel is the cost of handling cargo, which includes loading, checking, sorting, watching, and clerk hire on dock. Investigation revealed that the total actual cost per ton of general cargo handled in New York varied from $1.15 a ton to $1.65, and in the ports on the Atlantic coast the range in cost per ton was from $0.92 to $2.15. One interesting example is as follows:

Cargo handled 152.4 tons general.

Stevedoring	$137.00
Cooperage	75.00
Watching	70.00
Sorting and delivering	284.00
Total cost	$566.00

Average cost, $3.71 per ton.

One only need check up on a ship during the loading and discharging to realize where the money goes. This item alone, on an average, is one-fifth to one-sixth of the total expense and is seldom checked as to delays, waiting, overtime, etc. With proper supervision, even with the high rates of pay, this excessive rate per ton could be greatly reduced.

Third in importance in operating cost of a vessel are wages afloat. So very much unreliable data have been printed about this subject that great care was exercised to obtain only authentic data, and the rates of pay quoted on American vessels was taken from shipping articles which are on file in the commissioner's office. The rates of pay on foreign vessels were obtained from vessels in service and shipowners, and for the benefit of those who are interested the information is tabulated and herewith presented (page 125) in the hope that it will speak for itself.

The standard of living in this country is so different from that in foreign countries that it is absolutely unfair to compare American wages with those of foreign vessels.

One of the most unfortunate lines of reasoning today is that by cutting wages one obtains efficiency. It matters not in what capacity a man is employed, if the wages for that rating are higher than the wages for the same ratings in other lines, then the most efficient man will be found for the place.

Perhaps the reader may find in the scale of wages herewith presented sufficient explanation as to why the native born American does not adopt the profession of the sea.

Wage Scale Effected on July 1, 1922.

	U.S.S.B. scale	A.S.O.A. scale	Private owned American Actually paid		British		German		Danish		Swedish	
					£	$4.40	Marks	400 to $	Krone	1 krone 21½¢	Krona	1 krona 25½¢
Master	$270.00	$275.00	.....	.....	£45	$198.00	6,000	$15.00	....	.....	....	.....
1st mate	165.00	165.00	$150.00	$150.00	21–10	94.60	4,200	10.50	750	$161.25	600	$153.00
2nd mate	145.00	140.00	125.00	115.00	16	70.40	3,800	9.50	625	134.38	420	107.10
3rd mate	130.00	125.00	100.00	95.00	13	57.20	3,425	8.55	450	96.75	380	96.90
Wireless	90.00	90.00	90.00	80.00	13–10	59.40	.....	.....	....	.....	....	.....
Carpenter	70.00	70.00	45.00	40.00	12–10	55.00	2,750	6.90	345	74.18	300	76.50
Boatswain	65.00	.....	45.00	40.00	11–10	50.60	2,750	6.90	345	74.18	300	76.50
A. B. seaman	55.00	47.50	35.00	35.00	10	44.00	2,600	6.50	316	67.94	275	70.13
Ordinary seaman	40.00	35.00	25.00	30.00	5–10	24.20	1,200	3.00	200	43.00	180	45.90
Chief engineer	240.00	250.00	240.00	225.00	24–10	107.80	5,500	13.75	1100	236.50	430	109.65
1st assistant engineer	165.00	165.00	150.00	150.00	20–10	90.20	4,200	10.50	850	182.75	400	102.00
2nd assistant engineer	145.00	140.00	125.00	115.00	16	70.40	3,800	9.50	650	139.75	350	89.25
3rd assistant engineer	130.00	125.00	100.00	95.00	13	57.20	3,425	8.55	575	123.63	285	72.68
Deck engineer	70.00	70.00	45.00	.....	11–10	50.60	.....	.....	....	.....	....	.....
Oiler	65.00	55.00	40.00	42.50	11	48.40	2,750	6.90	450	96.75	290	73.95
Fireman (oil)	57.50	50.00	35.00	.....	.....	.....	.....	.....	....	.....	....	.....
Fireman (coal)	.....	50.00	.....	40.00	10–10	46.20	2,650	6.62	322	69.23	275	70.13
Wiper	50.00	35.00	25.00	.....	.....	.....	.....	.....	....	.....	....	.....
Coalpasser	.....	40.00	.....	35.00	10	44.00	2,400	6.00	215	46.23	....	.....
Steward	105.00	105.00	100.00	90.00	14–10	63.80	2,600	6.50	530	113.95	350	89.25
Cook	90.00	90.00	80.00	75.00	13–10	59.40	2,850	7.12	450	96.75	325	82.88
Baker	70.00	70.00	45.00	60.00	9–10	41.80	2,440	6.10	230	49.45	....	.....
Messman	35.00	35.00	35.00	40.00	8–10	37.40	2,440	6.10	90	19.35	80	20.40
Messboy	35.00	35.00	35.00	35.00	.....	.....	1,525	3.81	....	.....	....	.....

Much could be written about the subject of insurance—all classes—but it would not influence the prevailing opinion of those who should know the subject fairly well. Any discussion on this subject can be summed up by saying that when loss and damage are high the rate is high and when loss and damage are low the rate is low. This cost could be reduced by bonus to ships' officers and self-insurance.

The remaining items which enter into the cost of operation are either unavoidable or under the supervision of the personnel afloat, and if care has been exercised to select only efficient officers it naturally follows that they will produce efficient results.

The question of subsistence, while not very large in total cost, is most important in having satisfied personnel afloat, and sufficient care should be exercised to see that food is properly prepared and made appetizing instead of the all too common practice of serving improperly prepared and unpalatable food.

The Shipping Board has recently placed a limit on the cost of feeding of 65 cents per man per day. My experience is that this is a generous allowance, provided that it is judiciously expended.

In the matter of deck and engine stores it would be well to work out an annual schedule of allowances and requirements. In discussing this subject with one of the profession, I found that he had worked up data for a company covering its fleet of quite a number of vessels, and on an average the figures of cost allowance check very close for requirements. For example, a vessel of the 7,500 to 9,000 deadweight ton class was allowed:

Deck department	$17.30 per day
Engine department	19.15 per day
Steward sundries	5.25 per day

In comparing these figures with those of actual operation, they were found to be rather generous, and it only confirms the opinion that in these departments, with a fixed schedule, the former excessive cost can be reduced to a minimum.

Taken as a whole, one is impressed with the manner in which shipping is handled since the days of the World War, and while in many cases there is too much misdirected energy, the members of the profession realize that the time has arrived to establish the American merchant marine on a clean, efficient business basis, and to regulate the operating cost so that it will be on a par with international competition.

From a study of the data available, the writer is of the opinion that American ships can be made efficient, and excepting the excessive first cost, depreciation and overhead expense, can hold their own against any competition. To accomplish this result there should be closer relations between the executives of companies and the masters of their vessels. Masters should be selected for their efficiency and given absolute authority over the operation of their vessels. Chief engineers should be selected likewise and given absolute authority over their own department. The master should be furnished with complete cost data so that he can remedy high cost over which he has control and show the owner the excessive cost over which he has no control.

Managers and marine superintendents should be men who have served as master of a vessel. Superintending engineers should be men who have served as chief engineer of a vessel. Everything concerning the handling and stowage of cargo should be subject to the approval of the master of the vessel. If the master is to be held responsible, he should be given full authority regarding all details.

DISCUSSION.

MR. CLIFFORD D. MALLORY, *Associate*:—There is little I can say at this time, as I have been away from shipping activities for nearly a month. I think that Captain Sullivan has covered the salient features very well indeed and, as he says, the most important factor outside of the original cost of the property is the expense of operation. I might say that my experience up to 1917 was in the coastwise trade, so I did not have the experience of competing with foreign tonnage. In 1917 I went with the United States Shipping Board, where I acted as assistant director of operations until the end of the war. Naturally, that experience did not take economy into consideration.

At the end of my career with the Shipping Board I associated myself with a gentleman who had much experience in Scotland. He was born in Glasgow and brought up in the tramp school there. We have been in business since the fall of 1919. Naturally, I believed the school I was brought up in, the American school, was as good as any. I am the fourth generation in the shipping business, but when I became associated with Mr. Houston I found I had a great deal to learn.

We are operating about twenty-three vessels on an intensive plan. By this I mean all details receive personal supervision, and the following up of cost is as carefully supervised as is possible for any organization to do. Whenever you consider the figures and examine the cost, the principal item which attracts attention and shows to our disadvantage is the matter of interest and depreciation charges. American shipowners cannot compete at high values, which we have to set up for American built tonnage, in comparison with the lower values of foreign built ships, excepting with outside aid.

As to the details of operation, the question of fuel is one that requires a great deal of study. Exhaustive investigation of the proper purchase and use of fuel is essential, and with proper supervision of the fuel account I believe we can compete with anybody—that is, in oil burning. We are running a line to South Africa where coal is essential. We cannot carry enough oil for a round voyage and cannot buy oil out there at a price that would warrant our burning oil. We get a cheap grade of coal at Durban, South Africa, but it is inefficient. On the other hand, in the Mediterranean service we are burning oil on the round voyage.

The Shipping Board is starting a movement that is very essential and will be very helpful to those who will take advantage of the opportunity of gaining knowledge regarding the selection and proper use of fuel. The Shipping Board has instituted, at the Philadelphia Navy Yard, a course of instruction regarding the selection and use of fuel, which course should be of great practical value to all persons who are concerned with the uses of fuel oil on vessels. I have not been able, personally, to inspect their equipment, but I believe this is one of the important things that can be done to advance the operation of American ships. We have the advantage over our European competitors in having available large quantities of cheap fuel oil at our home ports. I have no doubt but what our navy knows more about the handling of oil fuel than any other navy, and the merchant marine should profit by that knowledge. The Shipping Board Committee will put it before those who are operating their ships in such a way that it will be very helpful.

As to the cost of stevedoring, I do not know where Captain Sullivan got his figures, but

I presume he got them from the Shipping Board records. It is a very hard thing to compare figures obtained from the Shipping Board records with those derived from private operating. In handling Shipping Board ships, the Shipping Board naturally must have all operators conform with certain rules and regulations because it is a government institution, and it is difficult, if not impossible, for the board to give the wide latitude to the operators of its ships that a private owner will.

We are only a small operator of ships, but we have an arrangement with the private owners who have placed their vessel property under our management whereby we have an absolute free hand in the management of their tonnage, and our reports and statements are in a very simple and brief form. In the management of Shipping Board ships I believe we have as much of a free hand as any of its operators, and by comparison we know that Shiping Board ships are very much handicapped in regard to expense as compared to privately owned vessels.

As to stevedoring as reflected on Shipping Board vessels, I believe there is a slightly higher cost on these ships than on privately owned vessels. Wages are the same, but the Shipping Board has a scale of contract prices which must be lived up to, whereas privately owned vessels' stevedoring is either done by the owner himself, where all profit accrues to him, or he can negotiate with the stevedoring companies, which would be to the advantage of the ship as against the Shipping Board plan.

Mr. James Donald, *Member:*—I am sure we are all very pleased to hear from Captain Sullivan about the efficiency in operation of steamships. I would like to ask Captain Sullivan, referring to page 123 of his paper, if these three examples are for American ships built by American companies. I think it would have been interesting to have had some statement regarding foreign ships, to see what the percentage is and if it compares with these three steamers.

On page 124 the captain says: "The standard of living in this country is so different from that in foreign countries that it is absolutely unfair to compare American wages with those of foreign vessels." Then on page 126 there is a very interesting paragraph where he says: "From a study of the data available, the writer is of the opinion that American ships can be made efficient, and excepting the excessive first cost, depreciation and overhead expense, can hold their own against any competition." I think the captain will have to include in those exceptions the cost of the wages, because on page 125 he gives a comparison of wages on different ships under different nationalities, and the American ships are the highest.

So I would like to see a detailed account of how he is going to compete with the foreigner if he excepts the first cost, the depreciation, the overhead expense and the wages. There is not much left. The captain then further says: "To accomplish this result, there should be closer relation between the executives of the companies and the masters of their vessels." I think Mr. Mallory will bear me out that the ship operator and the executives of the company work together very well with the masters of the vessels, and I do not see how he will make up the difference in operation between American ships and foreign ships, by having the executives of the steamship company working closer with the masters than they do at present.

Mr. John L. Bogert, *Member*:—I think I can answer one of the suggestions of questions brought up by Mr. Donald. I did not have time to have this blueprint (see table, p. 129) turned into a slide, but I understand it will be incorporated in the Proceedings.

Mr. Donald spoke of the desirability of comparing the figures in the papers with the figures of foreign vessels, to determine whether the percentages were alike, and for that reason I will say that the table covers the five years' operation of probably one of the most successful foreign lines in existence. I will not mention the company, but I will say that they started the first year—I have the figures here for about 34 steamers—cargo steamers, about half of them owned and half chartered, and at the end of the period they had practically sold all their steamers and had only motor ships. The only steamers which they retained were those which they had chartered. For that reason I think these figures will be very interesting to the Society, because they throw some light upon the transition which is taking place in the merchant marine and is bound to go on.

Items	Operating expenses	Year ending Dec. 31,1911	Year ending Dec. 31, 1912	Year ending Dec. 31,1913	Year ending Dec. 31,1914	Year ending Dec. 31, 1915	A. D. O. K. John L. Bogert
1	Coal and oil	$451,970 21.343%	$540,321 22.337%	$633,677 20.716%	$607,105 18.917%	$701,810 16.586%	Amount-dollars Percentage
2	Wages and provisions	$235,879 11.139%	$300,946 12.441%	$306,175 10.009%	$367,346 11.447%	$550,613 13.013%	Amount-dollars Percentage
3	Suez Canal, Panama Canal and harbor dues	$353,886 16.712%	$341,195 14.105%	$355,018 11.606%	$433,628 13.512%	$491,430 11.614%	Amount-dollars Percentage
4	Consular fees	$4,010 0.189%	$4,495 0.186%	$3,711 0.121%	$9,854 0.307%	$7,432 0.176%	Amount-dollars Percentage
5	Pilotage and towing	$50,668 2.393%	$59,251 2.494%	$67,075 2.193%	$72,124 2.247%	$71,342 1.686%	Amount-dollars Percentage
6	Loading and discharging	$256,870 12.130%	$300,382 12.418%	$401,238 13.117%	$384,147 11.970%	$436,138 10.307%	Amount-dollars Percentage
7	Classification, repairs, stores and maintenance	$132,422 6.253%	$131,414 5.433%	$120,792 3.949%	$219,933 6.853%	$253,034 5.980%	Amount-dollars Percentage
8	Steamers on charter	$191,084 9.024%	$222,907 9.215%	$520,629 17.020%	$368,421 11.480%	$226,423 5.351%	Amount-dollars Percentage
9	Agents' commissions	$112,428 5.309%	$142,857 5.906%	$188,643 6.167%	$166,048 5.174%	$288,479 6.818%	Amount-dollars Percentage
10	Insurance	$102,413 4.836%	$141,465 5.848%	$174,211 5.695%	$269,904 8.410%	$781,411 18.467%	Amount-dollars Percentage
11	Transhipment, conference rebates and claims	$198,871 9.391%	$203,905 8.429%	$255,713 8.360%	$274,957 8.568%	$361,389 8.541%	Amount-dollars Percentage
12	Telegrams, advertisements and sundries	$27,087 1.279%	$29,799 1.232%	$32,018 1.046%	$35,765 1.114%	$61,810 1.461%	Amount-dollars Percentage
	Totals	$2,117,588 99.998%	$2,418,937 100.044%	$3,058,900 99.999%	$3,209,232 99.999%	$4,231,311 100.000%	Amount-dollars Percentage
	Freight and passage money	$2,632,376	$2,994,943	$3,789,756	$4,060,797	$8,067,714	Amount-dollars

I will just summarize the percentages in the table that you are interested in. For the year ending December 31, 1911, when the company practically had only steamers, the percentage of the operating expenses for fuel was 21.34; the next year, when the company started in with motor ships, I see the change is very slight, 22.33. Then more motor ships were obtained, and the fuel expenses for the year ending December 31, 1913, were 20.71, and

for the year ending December 31, 1914 (interfered with, of course, by the war being on and what was happening then), the fuel expense was 18.91, and the fuel expenses by December 31, 1915, had sunk to 16.58. The vessels were practically nearly all motor ships. I have here not only percentages with regard to fuel consumption but the percentages for wages and provisions. They began, for the year ending December 21, 1911, at 11.13; the next year 12.44; the next year 10, and the next year 11.44, and for the year ending December 31, 1915, a rise in wages made it 13 per cent.

This chart covers some ten or twelve items, including classification, repairs, stores, and maintenance and another item, loading and discharging, showing all the way from 12 to 13 per cent.

The point I want to make in regard to this is—if you gentlemen will turn to the table on page 125 of Mr. Sullivan's paper and look down the column to the tenth item for the engineering department, you will find where our prices for chief engineer are $240, $250, and $225, and if you turn to the list of wages under the heading "Danish" you will find for the chief engineer $236, the amount being figured in dollars rather than krone; for the first assistant engineer, $182.75; for the first mate you will find $161.25 as against $275; in the case of the third assistant engineer, $123.63 as against $130.00; and then, in the case of the oiler, you will find $96.75 against $65.00. Apparently the Danish scale of wages in the engine room does not vary very much from our own.

I think that Mr. Mallory will bear me out and that Mr. Donald will also agree to it, that really, when you get down to it, this whole thing comes down to just one question from the standpoint of who puts money into American ships—what it is necessary to know, on the part of the American people, to induce them to give that assistance. In my opinion one thing is very essential, and that is the cost per ton-mile—the cost of operating the ship per ton-mile. I have been anxious to see the figures furnished by this Society, or by the operating department of a steamship line, which would show an analysis of the cost per ton-mile on the Atlantic. As Prof. Sadler will bear me out, they have been very thorough, with regard to lake shipping, as to the way in which they have handled that subject. They have taken the trouble not only to give the ounces of coal per ton-mile but to give us—and I do not see why we do not have that on other classes of ships—they have taken the trouble to give us the admiralty coefficient and the chance to determine, really, how good vessels are of similar kinds.

We all know it is not fair to compare ships of different lengths and different speeds, but the bulk of the carrying trade of the world is all done by boats of about the same speed and nearly of the same length, and I say in the majority of cases that they are all susceptible to a fair analysis on the basis of the admiralty coefficient. It may interest you to know that I have one blueprint which was furnished me very kindly by the American Shipbuilding Company, and the coefficient, you see, is very high.

$$\text{Constant} = \frac{D^{\frac{2}{3}} \times S^3}{\text{I.H.P.}} = 322.$$

D = displacement in tons.
S = speed in knots per hour.
I. H. P. = indicated horse-power.

I think, if you will analyze most of our salt water ships, you will find you have a wonderful result when you get to three hundred. I think most of the older members will remem-

ber that Mr. James McKechnie published a paper in the Proceedings of the Institute of Marine Engineers in 1901, showing how the coal expense per ton-mile went down with the length of the ship. That is only natural. We all know that surface friction is helping along the water as it goes further aft, and therefore the long ship has an advantage.

The 390-foot ocean ship steamed with 8 pounds coal for 100 ton-miles, and we got down on the 570-foot ship to 4.4—that was going from 390 to 570, coal in pounds per 100 ton-miles, the coal being burned by triple-expansion engines.

This data sheet I have here shows 2.1 pounds per 100 ton-miles which, turned into sea miles—which, of course, is the basis of the ocean calculation—comes to 2.4 per mile, so you can compare these two somewhat in your own minds. I reduced the mileage and got 9.64 knots, where Mr. McKechnie's figures showed a higher speed, but this boat had her place in the class of boats from 520 to 555, where the ocean-going boat is 4.97 and 4.8, as against 2.4 for the lighter boat.

I was extremely glad to hear from the professor yesterday, because I am intensely interested in this subject, and I believe that we will see a real new ship possible. We are going to build it, if we have to put the same brains and efforts into it that enable us to lead the world in sewing machines, locomotives, agricultural machines, typewriters and many other articles of production in this country. Germany tried to build the Ford automobile, and Germany is paying about one-tenth the actual wages that Henry Ford is paying. It was a failure in Germany. A Ford can be made in the United States and sent to Germany and sold cheaper in competition with the German made machine. We know that steel made in the United States is land down in Great Britain at as low a price as the English people can make it. I think that the day will come when we will be able to build a standardized ship as cheaply as it is built anywhere in the world.

I just want to give one or two more figures. With reference to the comparison of motor ships and steamers, a carefully calculated tabulation of the run of the Siam and comparing the two ships together, came to this—that the operating expense on the Siam was cut down to .16 of a mill per ton-mile, and in the case of the Arabien, one of the most economical steamships they could buy anywhere, built in England, it was .48 of a mill. That is, the expense of fuel itself was .04, and I have multiplied that by 4, because the fuel expense amounts usually to about 25 per cent of the operating expense. The point is this, that .16 of a mill per ton-mile is the actual cost of running the Siam against .48 of a mill per ton-mile in the case of the Arabien.

Mr. Christopher Story, Jr., *Member:*—In regard to standardization, I believe that, while it is very excellent in principle, it would be almost impossible to work out in practice, because we cannot build ships on a few standardized designs and efficiently and economically operate vessels of one or only several sizes and characteristics, for there are so many varied and absolutely different trades and conditions to be faced by practically every individual company that it would be very difficult, if not impossible, to standardize boats and construct them the same way that Mr. Bogert spoke of in standardized typewriters, automobiles, and the like, which indeed cannot at all be compared with ships.

I am not overlooking, however, the very beneficial results from standardizing certain ship parts, such as fittings, hatches and various machinery.

In regard to wages, I believe the argument that we cannot compete with foreign ships due to our higher wage scale has possibly been overemphasized, for Captain Sullivan very

ably points out that wages on an American ship amount to but 12 to 15 per cent of the total operating cost. It can be readily seen that, even though American wages were 50 per cent more than paid by foreign ships, the increase in operation would amount to a very small percentage indeed. I believe that the higher American wages could be, at least in some measure, offset by more efficient stevedoring and such additional savings as assisting in giving the ship a quick turn around.

A company that I was formerly employed by had compiled a very excellent pre-war comparison of German operated ships and American operated ships, and while it was shown that the German wage was much less, it developed that the costs per barrel of oil moved—for the vessels under comparison were tankers—were astonishingly similar. Therefore, instead of emphasizing our inability to compete on account of a higher wage scale, which in regard to the licensed ship personnel cannot be reduced to meet foreign wage scales due to our higher standards of living, other channels of more economical operation are open, such as: endeavoring to get legislation passed to relieve or have refunded to American ships in American ports and at the Panama Canal, tonnage dues, customhouse port charges; also, for the operator to make more advantageous contracts for towage, dock hire, by purchasing supplies in bulk by several companies pooling their requirements of standard stores and supplies, by keeping an eye open for economical fuel contracts, based on a sliding scale, etc., would tend very materially to place our ships on an equal basis with British, Norwegian and German ships.

In regard to the use of motor ships in the oil transportation business, which question I have investigated very carefully, if you could build a motor ship which could heat and pump out efficiently, without resorting to steam, the various grades of heavy Mexican oil now used so extensively for fuel, you would have a very economical transportation unit indeed. However, as it has not been practical to date to heat oil in a tank ship by other means than steam, oil companies have been very reluctant to adapt motor ships, as they are not in favor of a combination motor and steam installation. The above, of course, does not apply to transporting refined oil, gasoline, and other light oils which do not have to be heated.

Mr. E. H. Rigg, *Member of Council:*—Captain Sullivan's paper this year, and his discussion last year, on the economical operation of ships, have both been very interesting presentations in connection with the subject, and I want to congratulate him on having made so interesting a contribution on this occasion to a subject which we must all study. I do not appear before you as an operator; I am afraid that I belong to that class which must carry its share of the blame for high first cost, namely, the shipbuilder.

I want to bring out a point briefly in connection with what Mr. Bogert said. His comparison was on the subject of the fuel consumption per ton-mile. The people from the Great Lakes must remember this fact, which influences the comparison—the lake steamers operate only during the summer, that is to say, only during normally good weather. In the winter the lakes are largely frozen over and ships do not run, except in a few special cases. On the other hand, the ocean carrier operates also during the winter and must buffet the severities of winter weather on the ocean. That must be remembered when you compare the fuel consumption of the lakers and ocean ships.

Another point is, as Dr. Sadler tells us in his paper of this year, the Great Lake waves do not appear to be as severe as ocean waves. Now, if they are not as severe, it is obvious that the ocean ship must be given a handicap for the heavier waves when comparing fuel per ton-mile.

PROFESSOR SADLER:—I would point out, against that, that the interest and depreciation charges have to be spread over six months instead of over a year.

MR. RIGG:—In a discussion of total operating costs, Dr. Sadler's point is well taken; we are, as I understand it, discussing fuel costs per ton-mile and I do not see where interest and depreciation come in.

MR. HENRY G. SMITH, *Member*:—I have nothing to add to the details of this subject of "Efficiency in the Operation of Steamships," but I think we are particularly indebted to Captain Sullivan for bringing out some very salient facts and in giving us some actual data regarding the various matters which should be considered in the economic operation of steamships. My personal opinion is that we have been fooling ourselves for the last fifty years by not facing the facts, the principal reason for which has been an absence of reliable facts upon which to make a comparison. With the true facts before us it is self-evident that you cannot build ships or operate them as cheaply in this country as you can abroad. A previous speaker, who believes that we will be able to build and operate as cheaply in this country as abroad without some outside aid, is certainly an optimist, and I cannot let his belief go unchallenged, as I am very sure that you cannot possibly build or operate ships in this country as cheaply as abroad with the differential in wages and the differential in operating expense that now exists. The reason for it is that ships are not like Singer sewing machines or Ford automobiles—that is, built in great numbers and repeat jobs—but in ships there are very few duplicates and there is, therefore, very little opportunity to make use of the experience you gained in building one ship in the production of a second or third as there are comparatively very few repeat operations, whereas in the Singer sewing machine and Ford automobile referred to there are thousands of them manufactured and every part is a repeat operation. The first essential toward low cost of ship construction is ships to build, and in the absence of some aid that will give us ships to build there is, of course, but little opportunity to reduce the cost which comes from quantity production and which to a considerable extent exists abroad.

I hope the Society may be favored in the future with still more papers of the type which Captain Sullivan has presented, as they will be of real value in connection with our future study of this subject.

PROFESSOR EVERS BURTNER, *Member* (Communicated):—This paper by Captain Sullivan is a notable addition to the number recently presented which consider the problems of ship operation. I only wish that the press would educate us all to the conviction that American shipping in foreign trade represents practically our only unprotected industry. While most of our port captains, marine superintendents and port engineers have had training as masters or chief engineers, I feel that the shore staff should include a man with shipbuilding and ship repair experience.

All of us agree with Captain Sullivan that with plenty of cargo the time spent in port should be reduced as much as possible. However, to the writer's best knowledge no convenient method of rapidly following up the delays in a fleet of vessels has been advanced. Mr. Ralph Emery, president of John S. Emery & Company, Inc., of Boston, suggested a semi-graphical log sheet, which has been used by his company in operating several lines of vessels. The master or agent advised the manager as to the vessel's operations, and the latter immediately entered this news on the log by the proper characteristic line, together with any other

important news. The home office, therefore, knew exactly what the vessel was doing and had done. Inspection of the log sheet will furthermore show that columns provide a summary of the time spent in the various operations, and also by the use of similar log sheets for the whole year. Thus vessels could be easily compared as to steaming times, discharging, loading, repairing, demurrage, bunkering or other delays, and allowing for unavoidable circumstances, credit or censure could be given where called for.

I heartily agree with Captain Sullivan's plea for more competent masters, but present methods require that a ship's schedule be planned far ahead in order to ensure cargo being ready for her. Furthermore, it was felt that this log sheet would eliminate some of the red tape by serving to simplify and to reduce the number of formal deck department logs.

Mr. G. Edward Smith, *Member:*—There are one or two points I would like to bring up in connection with this subject, although I have no information to offer. The paper presented by Captain Sullivan is, I believe, a splendid start. One suggestion which I think might be of service is that it would be a great advantage if a committee of the Society, composed of both operators and shipbuilders, could get together and compile definite information on costs per ton-mile, costs of operation and costs of other details. We might then be able to bring our merchant marine back to its standard before the Civil War, when it led all other countries.

In the table on page 123 you will notice the cost of fuel and of cargo handling is practically 50 per cent of the operating cost of a ship. Wages are relatively a small item. Rather than place ourselves too much in opposition to labor by agitating for a wage reduction, it would seem to me to be better to reduce these two large items. I am convinced that, by comparing of notes by various operators and shipbuilders, both these items could be materially cut. A reduction of 10 per cent on these two items is four times the reduction of 10 per cent in wages.

As to the cost of shipbuilding, of course, ships cost more in this country than abroad. There was one fact I noticed when living abroad, and that is that the shipowner in this country determines to a much larger degree what he is going to purchase than the shipowner does in Europe. In England, or along the Clyde, the shipowner wants a certain vessel, and he goes to the shipbuilder building that type of ship and the shipbuilder tells him what he is going to get. In our dealings with owners in this country, it is dictated down to the smallest item what the owner is going to have. It seems to me that by a method of standardizing and comparing ships and service, we would get to a point where a decided saving could be made in the cost of shipbuilding in many material respects.

In the case of stevedoring and demurrage, there is not sufficient understanding at various ports as to the necessity for the quick loading and unloading of ships and the great necessity for proper equipment to handle the cargo efficiently. Demurrage is a considerable item at times. If a better equipment for handling cargo could be put into use, I think a decided cut in this expense could be shown.

Mr. Campbell MacMillan, *Visitor:*—I do not wish to detain you further than to make an inquiry and a suggestion. It is evident from the remarks we have heard this morning that there is one item lacking in making up accounts, and that is the variation of the fuel consumption from time to time. I refer to the effect on the cost of operation, not averaged over long periods, but where it can be averaged over comparatively short periods. The necessity for this distinction was emphasized by the discussion between Dr. Sadler and

Mr. Bogert on the relative cost of operation on the Great Lakes and at sea. It seems to me that some of the gentlemen who took part in these discussions might be able to furnish us with some idea of the variations which would occur due to the seasons of the year, and due to such weather conditions as Mr. Mallory referred to.

We are in a position now, with more efficient methods of handling and keeping control of ship movement and equipment, to obtain such information, and yet no effort seems to have been made to keep records of the variation of the fuel item. So far no such information has been available, in the form of general data on this subject accessible to those who are interested.

For instance, if an estimated figure were given by an expert as to the handicap on the ocean-going liners, due to the difficulties of operating in heavy weather during the winter season, compared with the summer season, we could form a clearer idea as to the possibilities of comparing the effect of diverse conditions on fuel costs for various classes of trade.

CAPTAIN SULLIVAN:—This morning I met a very good friend of mine who said: "Mr. Sullivan, I read your paper, and while it was very good as far as it went, you must have some further and more decided arguments that you could present." "Well," I said, "I have not attempted to go into the subject further," and my reason for that, gentlemen, is this—that a little knowledge is a dangerous thing. We can bring facts before people, but it is impossible for a human being to force these facts into the heads of other men. I am not 100 per cent perfect, and I do not pose to be any such thing. I am as closely connected with those who own the vessel of which I am master as it is possible for one human being to be closely connected with another when they are not related, and the results obtained have been obtained in the face of bitter competition and adverse criticism. It is not the first time I have made that statement, even in this meeting.

There is a marked difference between the operation of a ship in winter and in summer, and the figures which I have given are for a period covering both.

I have seen the time when it took me twenty-two days to come from Antwerp to New York, and I have made the same passage in 11.5 days, and that represents the difference between good weather and bad weather. Of course, in foggy weather, the engineer reduces the speed of the boat.

The most important criticism that I have heard here this morning was by the good gentleman who says we can produce better results if we spend more time on the equipment for handling cargo. That is the best statement I have heard. We can improve our methods of handling cargo by machinery.

I wish you good gentlemen who are naval architects and ship designers could take time and study the European system of installing what we call permanent grain fittings, by which, when the vessel has an emergency cargo of grain, we do not have to build a lot of grain fittings to comply with the underwriters' requirements. That is something which involves an expenditure of approximately $2,000 or $3,000. Two years ago I wanted that done, and at that time the cost of putting in those fittings was frightfully high, and I backed down and did not have it done.

The main difficulty in regard to fuel, and which tends to increase its cost, is that when your contract runs out and you go out to renew it, you find that the cost of coal has gone up like the German mark. When you go to buy fuel abroad you will find that the cost is high and the tonnage short; I have had as much experience with buying fuel abroad as any-

body else, and I have never been able to come within 20 tons of a just delivery of the fuel—that is, my calculation did not agree with the calculation of those who sold the coal within 20 tons.

The cost of operation of an American ship and the cost of operation of a foreign ship over the identical run are practically the same. We will take a ship, say that runs from New York to Liverpool, and one under the British flag and one under the American flag, and the only difference in the cost of operation is on the ship itself—stevedoring and labor charges about the same, port charges a little different, and the loading and unloading of the cargo about the same, and fuel is the same; the only difference is on the ship, and that is where you must study the possibilities for making improvements. I have maintained for years that these great organizations are wonderful successes who pay men for their brains and ability and require them to work. I do not wish to say anything that would reflect in any way on the character of the men whom we employ on shipboard, but we must pay sufficient to get the proper type of brains to operate these ships, so that we may get the results, and we must go to it.

I do not think the time will ever come when you can build a ship in America as cheaply as you can build it abroad. That is because the American workmen receives more money, and his work is better than in many other places.

It may be of interest to you gentlemen, who think it is a simple matter to compare costs of operation, for me to say that I took a cargo of 200 tons of grain to Hamburg, and the American longshoremen got 80 cents an hour, and the German longshoremen got 450 marks per hour, and over here the rate of exchange for the mark was 3,000 marks to the dollar.

A doctor came on board my ship and said "Captain, can you give me a little something to eat? I get 15,000 marks a month, and I have a wife and three daughters." That is one reason why we cannot compete with such conditions.

THE PRESIDENT:—Gentlemen, I am sure you have been interested in hearing the paper which has been presented to us by Captain Sullivan, and the most interesting discussion which has followed it, and on behalf of the Society, I extend the thanks of the Society to Captain Sullivan for his valuable paper.

The next business will be paper No. 8, "A 1,650 Horse-power Gasoline Fire Boat," which will be presented by Mr. Arthur D. Stevens, a member of the Society, who comes from Jacksonville, Florida.

Mr. Stevens then abstracted his paper.

A 1,650 HORSE-POWER GASOLINE FIRE BOAT.

By A. D. Stevens, Esq., Member.

[Read at the thirtieth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 8 and 9, 1922.]

While the need of a fire boat for a city having 7 or more miles waterfront, over half of which is actively used by commerce, is self-evident, the special conditions existing at Jacksonville made it somewhat difficult to design a boat that would satisfactorily fill all the requirements.

While a portion of the frontage is occupied by large industrial plants and extensive transportation terminals that demand a powerful boat of great capacity, yet the main business portion of the city is bordered by narrow and shallow slips and a collection of wooden piers and structures which menace the valuable abutting structures on solid ground.

A steam fire boat of sufficient capacity could not be used to any advantage in this last-mentioned locality as its draught and size would be too great.

A dozen or more years ago the writer endeavored to satisfy these conditions by designing an all-gasoline motor-driven boat of about 4,500 gallons per minute capacity, which could have been built at that period for less than $50,000. The use of gasoline on so large a scale did not appeal to the fire department which was still wedded to the steam fire engine and had no use for gasoline, and so the project was abandoned for the time.

Four years ago, after the department had been converted to automobile trucks and motor fire engines, the fire-boat project was revived and the design of motor fire boat brought up to date.

Financial and political considerations, however, held the question up until finally a compromise was effected by deciding to purchase one of the government 110-foot wooden subchasers for a nominal sum and fitting her up as a fire boat.

The writer submitted designs and specifications for the remodeling and conversion of S. C. 145, the boat the city had bought, which were accepted and ordered carried out under his directions as engineer in charge. Proposals were advertised for and finally awarded, and the boat has been completed.

As far as the writer can ascertain, this is the first complete full-powered fire boat to be entirely motor driven.

As a capacity of not less than 5,000 gallons per minute at 150 pounds pressure was desired and it was necessary to retain two of the three 220-horse-power propelling motors, it will be seen that there was no room to spare in a light wooden hull 110 feet by 14 feet by 8 feet.

The plan adopted was to build up the hull for 50 feet amidships, 3 feet higher, using all steel construction. This was done by first clearing away everything in this space clear to the skin of the hull, cutting off deck beams flush with shelf and putting on an inside facing strake which, with the waterway and shear strake, formed a complete box girder. (See Figs. 4 and 5, Plate 45). Steel angle frames were mortised through the waterway alongside every

other wooden frame giving a 24-inch spacing, these angle frames extended down 30 inches into the wood hull and were bolted both to the frame alongside and to the outer planking.

The ¼-inch steel side plates extended 6 feet beyond the bulkhead at each end and were fastened down by lag screws every 6 inches through a 2½-inch by 2½-inch bounding angle.

The deck beams were 6-inch channels with 2-inch by 2-inch brace angles instead of gussets. Deck plating 3/16-inch finishing at sides and ends with 2½-inch by 2½-inch cover angles.

The pilot house at the forward end is all steel of a little lighter scantling. This gave a machinery space 50 feet long, the full width of the hull. The after 20 feet of this was taken up by the propelling machinery and auxiliaries, the arrangement of which was left undisturbed save by the removal of the center 220-horse-power "Standard" engine, together with its shaft, wheel and rudder.

In the forward 30 feet there are installed four 8-inch three-stage De Laval centrifugal fire pumps, each directly connected to a 300-horse-power "G. R. C." type Sterling eight-cylinder motor. These pumps are right and left and are arranged two on each side with a working gangway 30 inches wide between. The pumps are in the center and take their suction from a 10-inch fore and aft suction main between them. This main is fed by four 10-inch seacocks, two at each end, each with its stop valve and a 2½-inch washout connection from the discharge main between the stop valve and out-board strainer. The suction main has two flexible diaphragm joints to take up any working of the hull. The pump suctions connect through 8-inch standard ells and gate valves to 8-inch by 10-inch standard crosses in the suction main. By this arrangement all the pumps can draw from any one or more, or all the seacocks. As the boat may have to operate in shallow muddy slips the consequent danger of stoppage from choked seacocks is thus practically eliminated.

The discharge connections are on the outboard side of the pumps and connect to the 10-inch central overhead discharge main through 8-inch by 6-inch reducing ells, 6-inch swing check valves, 6-inch copper bends and 6-inch stop valve.

Owing to the sharp dead rise of the hull it was not practical to set the pumps low enough to prime completely by gravity, and a Nash "Hytor" exhauster, driven by an electric motor, creates a vacuum system which primes the pumps almost instantly.

The outlets from the discharge main consist of two 8-inch risers forward and aft, each with a six-valve turret head surmounted by a 2,500-gallon "Invincible" monitor nozzle, and a 6-inch riser to the top of the pilot house with a similar nozzle.

All valves and fittings throughout the suction and discharge systems are regular manufacturers' standard and extra heavy patterns, except the sea chests and turret heads.

Both suction and discharge mains have a central stop valve allowing forward and after sections to be operated independently.

Since there are in the 50 feet by 14 feet machinery space forty-six gasoline motor cylinders aggregating 1,650 horse-power, the question of ventilation is of prime importance. This is provided for by two 2,000-cubic-foot-per-minute electric blowers, taking air through the after end of the steel trunk house and delivering it through ducts abreast of each propelling and pump engine.

To remove the hot air there is a 26-inch electric ventilating fan in the 42-inch ventilator stack. In addition there are two 5-inch electric exhausters, taking air from the bilges of the engine and gasoline tank rooms. There are also sixteen 14-inch air ports in the sides of machinery space.

In the 20-foot space used for the propelling machinery are two 220-horse-power six-cylinder air starting and reversing "Standard" motors, each driving a 48-inch diameter by 42-inch pitch three-bladed wheel of "Case" outward thrust pattern. Back of each wheel is a bronze rudder of balanced type. This arrangement of wheels and rudders gives much better handling qualities in close places than are usually found in craft of these proportions and does away with one of the main objections to the use of these subchaser hulls for this purpose.

A 4½ K.W. "Standard" auxiliary air compressing and generating set furnishes air for handling the main engines, electricity for lights and motors, and for keeping charged two 75-ampere-hour 110-volt storage batteries. These, with the necessary switches and instruments and the two electric blowers, take all the available engine-room space not required by the main engines.

Including a 2-horse-power electric fire-alarm siren, there are seven motors and a search-light, as well as the lighting system, to be supplied with current. The circuits and switches are so arranged that either battery or the generator can carry the full load, or it can be divided between the three.

The gasoline supply (1,200 gallons) is carried in the compartment aft of the engine room, from which it is cut off by a watertight steel bulkhead; it is stored in three No. 12 gauge copper tanks, 36 inches by 96 inches, from which it is forced to the motors by air pressure from the air storage tanks. All openings to tank space are protected by wire gauze screens.

Each propelling and pump engine exhausts directly out through the side of the hull, the exhaust being cooled and muffled by direct introduction of circulating water discharge.

On the forward and after decks are hose boxes each containing 1,000 feet of hose. A 3-foot heavy iron rail extends around the main and pilot-house decks. All the steel decks are fitted with removable wooden gratings. Heavy iron chocks and double bollards are fitted to each quarter of the steel trunk house.

While the contract specifications of the pumping units called for a delivery (for each unit) of 1,250 gallons per minute at 150 pounds pressure and 1,100 gallons at 250 pounds, the tests at the builders' factory showed nearly 1,500 gallons at the lower pressure and 1,200 gallons at the higher. Tests at lower pressure gave a capacity of 1,750 gallons at 100 pounds, making a total of 7,000 gallons for the four pumps.

A special feature of this pump installation is that no compounding of the pumps is required to deliver the high pressure—250 pounds. The entire range of pressures is obtained by varying the speed of the engines.

These motors respond as readily to the throttle as a steam engine, and changes of speed from 1,000 to 1,500 revolutions produce all the range of pressure required.

The engines at 1,500 revolutions run very smoothly and develop 300 horse-power, with a gasoline consumption of less than 0.66 pound of gasoline per horse-power hour.

The position of the propelling engines was so near amidships that it necessitated placing the pumping machinery further forward than was desirable for proper trim. To correct this about 10 tons of iron ballast were stored in the after end of the engine-room bilge.

The running trim is 7 feet draught forward and 6 feet 6 inches aft.

Some apprehension was felt that there would be an excessive list from the nozzle reaction when discharging full capacity directly abeam, but tests made showed only 5 to 6 degrees list under this condition.

Preliminary runs have developed a speed of 15 miles, with engines making 450 turns.

Summing up, the city of Jacksonville has secured, at a cost of less than $70,000, a fire-boat of 7,000 gallons per minute capacity and a speed of 15 miles per hour, with a displacement of only 110 tons and a draught of 7 feet.

No quarters are provided on the boat, the crew being quartered in a station house built alongside the slip where the boat is stationed.

TABLE OF DATA.

Length of hull (feet)	110	Number propelling engines	2
Breadth of hull (feet)	14	Number cylinders each engine	6
Depth of hull (feet)	8	Bore of cylinders (inches)	10
Draught forward	7′	Stroke (inches)	11
Draught aft	6′ 6″	Speed (builders' rating) (r. p. m.)	460
Displacement (tons)	110	Horse-power (builders' rating)	220
Length of machinery space (feet)	50	Diameter of propeller (inches)	48
Width of machinery space (feet)	14	Pitch of propeller (inches)	42
Height of machinery space (feet)	11	Number of blades	3
		Projected area of blades (%)	32

Number of pumps	4
Type	Three-stage centrifugal
Size (inches)	8
Speed (r. p. m.)	1,000 to 1,500
Capacity (g. p. m.)	1,750
Number of cylinders each motor	8
Bore of cylinders (inches)	5¾
Stroke (inches)	6¾
Horse-power (builders' test) 1,500 r.p.m.	300

The general arrangement of machinery is shown in Figs. 1, 2 and 3, Plate 44, of accompanying plans. The special arrangements of pumps and piping, as well as the method of joining steel work to wood, is shown in Figs. 4 and 5, Plate 45, which are sections through seacocks and pump suctions respectively. Fig. 6, Plate 46, is a diagram showing pump performance.

Trial tests made since the boat has been completed have been very satisfactory; a speed of 12 knots was obtained without exceeding 425 revolutions of the propelling engines, which, under full power, gave 475 turns. At full speed ahead the boat was brought to a complete stop in less than one and one-half lengths distance and 22 seconds time. A complete turn was made at full speed in a 125-yard diameter circle. The boat also answered the helm while backing with both engines.

Two-hour tests of the pumps by the underwriters' representatives gave a sustained capacity for each of the four pumps of over 1,500 gallons per minute at 150 pounds pump pressure, or 20 per cent above contract requirements. Two full 3-inch turret streams were sustained at 160 pounds pressure, and one 3-inch stream was projected vertically over 330 feet with 250 pounds pump pressure. The accompanying photographs show some of these performances and also show the arrangement of machinery and pumps in engine room. (Plates 47 to 52.)

DISCUSSION.

THE PRESIDENT:—Gentlemen, you have heard the presentation of Paper No. 8, "A 1,650 Horse-power Gasoline Fire Boat," by Mr. Arthur D. Stevens, Member. The paper is now open for discussion.

If there is no discussion, I desire, on behalf of the Society, to express our thanks to Mr. Stevens for this very interesting paper, and for having come all the way from Jacksonville to read it to us and tell us about it.

I am sorry there has not been some discussion, but I presume this paper is something that is unusual, and not many of the members feel they are in a position to discuss it. Of course, as there has been no discussion, it will not be necessary to ask for any replies.

We will now have Paper No. 9, entitled "The Longitudinal Strength of Rigid Airships," by Prof. William Hovgaard, a Member of the Society.

Professor Hovgaard then presented the paper.

THE LONGITUDINAL STRENGTH OF RIGID AIRSHIPS.

By Professor William Hovgaard, Member.

[Read at the thirtieth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 8 and 9, 1922.]

INTRODUCTION.

The general strength of rigid airships is a problem so much akin to the corresponding one for ordinary ships that it is believed to be of interest to the members of this Society, the more so as some of them are actively engaged in the design and construction of this new craft. Yet it must be admitted that the structure of an airship is in several respects radically different from that of an ordinary vessel and in fact from any construction hitherto attempted by man. The extreme requirements to a saving in weight make it necessary to adopt an entirely novel combination of girders with steel wires of high tensile strength. The girders are constructed of the lightest metal we possess. At the same time the factor of safety is cut down to a figure which would not for a moment be considered either in shipbuilding or in civil engineering. These features necessitate a nicety of design, an accuracy in calculations, and a perfection in construction unparalleled in structural work in the two branches of engineering just referred to. They call for an extensive theoretical and experimental study of a most difficult nature, involving, as they do, new and intricate problems in structural design and in aerodynamics. An airship in its complete form is one of the highest and boldest achievements in engineering.

The present paper results from a study of this subject carried out by the author when retained by the Navy Department in a consulting capacity in connection with the design of the rigid airship ZR-1. The fact that the paper introduces for the first time a new and important subject to the members of this Society will, I hope, serve as an excuse for its great length.

I. GENERAL DISCUSSION OF THE STRUCTURE OF A MODERN RIGID AIRSHIP.

For the sake of those who are not familiar with the general construction of airships a brief description is given of the principal features of a ship of the Zeppelin type and I choose as an example the German L-49, which was completed in 1917. In the fall of the same year she was forced down intact at Bourbonne-les-Bains and was captured by the French, who made a careful survey of her. She has served as a basis for the design of the ZR-1, now under construction at Philadelphia and Lakehurst.

Referring to Plate 53, the form of the sections of L-49 is that of a fairly regular polygon, approaching very closely to a circle. The longitudinal main girders, with the exception of the two bottom girders, are equidistant, 6 meters apart, and midway between them run lighter, so-called secondary longitudinals, which cannot, however, be considered as integral parts of the structure, since they are not in efficient shearing connection with the main girders or with one another. The two bottom or M-girders are more closely spaced and

form together with an inner longitudinal, the N-girder, a triangular "keel girder." The polygonal form of the structure is preserved by means of main frames spaced 10 meters apart, assisted by intermediate frames placed midway between the main frames. The longitudinals and the frames are all connected with each other at their points of intersection, but the connection between the secondary longitudinals and the main frames is very indirect. The points of intersection are referred to in the following as the joints. The structure so far described is incapable of resisting shearing and torsion. If there were no interconnections between the longitudinals, they would be able to move lengthwise relative to each other without meeting much resistance; the frames could distort freely, and the whole ship could twist around its axis. In order to prevent these actions the rectangular panels formed by the main longitudinals and the main frames are each of them spanned by two diagonal wires, which we shall refer to as the "shear wire" and the "counterwire," meaning by the former that wire which takes the shearing load in any given case. When an airship is in the hogging condition, the wires that are inclined downwards towards the bow forward of the section of maximum bending moment and downwards towards the stern aft of that section are the shear wires. Another set of somewhat lighter wires span in the same way the panels which are bounded horizontally by the main longitudinals and vertically by consecutive main and intermediate frames. These wires, shown dotted in Plate 53, are referred to as the secondary wires; they are omitted in certain parts of the bottom, but are fitted completely in the upper part of the ship and in those parts of the bottom where the cars are suspended. Locally there are deviations from this system of wiring, but on the whole there is almost perfect continuity in form and structure, more so than in the shell construction of an ordinary ship. The main frames are stiffened in their own plane by a system of diametral and chord wires, which effectively prevent distortion in a transverse plane and play the same part in the structure as transverse bulkheads in an ordinary ship.

The structure of an airship differs essentially from that of an ordinary ship in that the shearing is taken entirely by wires incapable of resisting compression, although not, as shown in the following, incapable of transmitting compressive forces so long as they are taut. When an ordinary ship is subject to shearing, the lines of principal tensile and compressive stress run continuously along the shell plating, crossing each other at right angles. When subject to combined shearing and bending, the shearing stresses attain their maximum value at the neutral axis and the lines of direct stress are here inclined at 45 degrees to the horizon.* In an airship the lines of stress will tend to arrange themselves in the same way, but this is to some extent prevented by the peculiarities of the wired structure. While the shear wires are in tension, the counterwires, even if set up with an initial tension, are liable to be slack when the shearing deflections are very great. The tensile stresses at the neutral axis are able to act along the shear wires in diagonal lines, much as they do in the shell of an ordinary ship, but if the counterwires are slack, the principal compressive stresses, which tend to act at right angles to the tensile, find no direct path and are forced to flow partly through the longitudinals, partly through the frames, which together form the rigid skeleton of the ship. At the joints, however, we may expect to find the stresses distributed as in a continuous plated structure and the principal direct stresses at the neutral axis inclined at 45 degrees to the horizon. The conditions are similar to those which would exist on the sides

*The general flow of the stresses in the shell plating of a ship is illustrated in Fig. A, Plate I, page 46, in the author's book on "Structural Design of Warships."

of an ordinary ship if openings were cut in the shell plating between the frames and longitudinals as indicated in Fig. 1, where a thin diagonal strip of plating, incapable of resisting

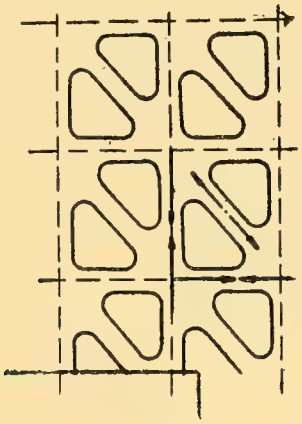


FIG 1.

compression, is left in each panel. Here, again, the lines of compressive stress at the neutral axis will be directed along the frames and longitudinals. This peculiar distribution of the stresses will locally influence the strains in the structure and may, for instance, cause a longitudinal to be in compression between two joints, which themselves are subject to a tensional stress across a transverse plane through the center of the joint. This anomaly exists where strong shearing is combined with a small bending moment. It follows that only at the joints are the stresses distributed as in a continuous plated structure, and if we want to apply the ordinary theory of bending to determine the stresses, it appears from these simple considerations that it is best to consider sections at the frames taken through the center of the joints.

II. METHODS OF CALCULATION.

In order to calculate the stresses in the girders and in the wires, it is necessary first to consider, in a general way, the mode of loading.

When an airship is floating in statical equilibrium, the straining actions are due solely to the buoyancy and the weights which are readily calculated. The buoyancy is very evenly distributed (about as in a submarine) and part of the load—viz., that due to the hull—is distributed practically in the same way; also the consumable weights: fuel, ballast, ammunition, etc., are fairly uniformly distributed, but the remaining load resides chiefly in the cars with their machinery, the weight of which is applied in a rather concentrated manner suspended under the hull. The consequence is that in the vicinity of the cars the shearing has maximum values at points where considerable bending exists at the same time. In one or more places, on the other hand, the conditions of loading may come to resemble those existing in the axle of a carriage, where pure bending, practically without shearing, exists between the bearings. The load and buoyancy are so arranged that the ship is normally in hogging condition so as to ensure that ordinarily only the lower longitudinal members shall be in compression. This is desirable because failure of the longitudinals is much more likely to occur in compression than in tension, and the heavy keel structure which runs along the bottom of the ship is better able to stand compression than the top girders.

When a ship is in flight, it is subject to aerodynamic loading and inertia forces which are superposed on the statical load. The aerodynamic forces seem to produce the greatest bending moments when the ship is going at an angle of pitch in rectilinear flight, in which case the aerodynamic load curve has a marked hump at each end.

The problem of determining the magnitude and distribution of the dynamic forces is outside the scope of this paper; it shall here merely be stated that it forms one of the most difficult problems in airship design, because it is not as yet fully cleared up experimentally. It is known, however, that unless airships are handled carefully when going at high speed, and especially at low altitudes, the dynamic stresses are likely to exceed the statical stresses very considerably. This was one of the lessons of the R-38 disaster, which has led to a more complete study of this branch of the subject. Before that disaster occurred, it was generally thought sufficient to provide for the static forces, the assumption being that the dynamic forces would be less serious.

It is assumed that the forces, to which the ship is subject, are known and that curves of shearing force and bending moment are constructed corresponding to the various conditions of loading. The problem here to be discussed is how to calculate the stresses in the main structure from these data.

At least two modes of calculations have been used by designers of this craft. One, the *"method of transverse shears,"* described by Mr. E. H. Lewitt in *Aeronautics,** consists in calculating the tensions in the shear wires due to shearing only and resolving the forces so obtained along the longitudinals. By a summation of these forces, beginning from either end of the hull, the end load accumulated at any point of the longitudinals in determined. The longitudinals are regarded as consisting of rigid bars connected at the joints by frictionless hinges and the deflections of the hull are supposed to be wholly due to the stretching of the wires. As this method takes no account of the elastic strains and stresses due to bending of the ship as a whole, it cannot give a complete solution.

The other method, referred to as *"the method of bending moments,"* is based on the ordinary formula for bending and gives the longitudinal stresses in the girders, but as explained below, the assistance rendered by the wires in taking the longitudinal bending forces has been hitherto disregarded. The tension in the wires due to shearing can be determined in any panel by considering the effects of shearing in each frame space separately.

The main purpose of this paper is to show that the bending method is essentially sound, and that with certain modifications it is reliable as a means of comparison between the strength of different airships. The shear method, on the other hand, in spite of its laboriousness, is incomplete because the elastic elongations and contractions of the girders are neglected. The relative validity of the two methods has long been a vexed problem, and it is evidently of the greatest importance that this fundamental question should be definitely settled.

It is convenient for the sake of clearness to approach the problem synthetically, building up our conception of the complex reactions in an airship from the most elemental cases and finally, by combining these, to pass on to the more complete and general case. With this in view the author has made a study of a number of simple cases, but unfortunately it was impossible to include all of these in the present paper, which is already rather long.

**Aeronautics*, London, Feb. 12, Sept. 9, 1920.

III. RECTANGULAR PANELS.

The panels here considered consist of two vertical bars, in some cases called the posts or frames, A_1C_1 and A_2C_2, denoted by (1) and (2), see Fig. 2, and two horizontal bars, marked a and c, sometimes referred to as the longitudinals or girders. The four corners of the panel are called the joints, which are supposed to offer no resistance to distortion. There may be one or two diagonal wires marked (1) and (2). The frames are assumed to be absolutely rigid, but the girders and the wires are elastic. When not otherwise specified, the wires are supposed to be initially just taut before any forces are applied to the panel. Frame (1) is held fixed and the effects of gravity are disregarded. The horizontal forces acting at the joints are denoted by P, the vertical or shearing forces by Q, the total tension in the wires by T, and the end-forces acting on the girders by F, all with suffixes as required. The girders are of duralumin, the wires of steel.

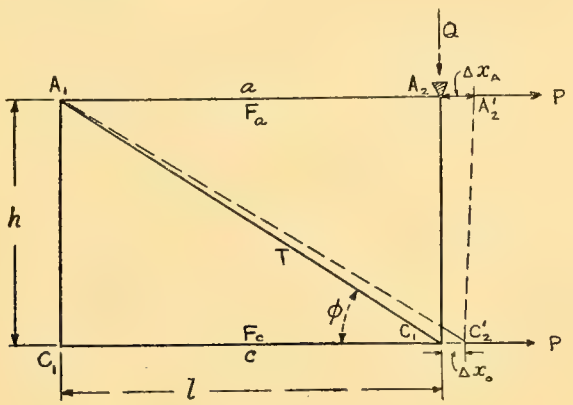


FIG. 2.

E_D = Modulus of elasticity of the girders (4,700 ts. per square inch).
E_w = Modulus of elasticity of the wires (13,500 ts. per square inch).
a = Sectional area of girders.
a_o = Sectional area of wires.
l = Length of girders.
h = Height of frames.
ϕ = Angle which the wires form with the girders, $\tan \phi = \frac{h}{l}$.

Case 1. Tensile P-forces act on the panel. The fictitious bar.—Referring to Fig. 2, equal and parallel P-forces act at A_2 and C_2. The tendency of A_2C_2 to move upwards is prevented by a fixed support at A_2, against which the panel presses with a force Q, creating an equal and downward reaction. The bars a and c elongate; the wire is stretched and put in tension. We have

$$F_a = P, \qquad F_c + T \cos \phi = P.$$

The elongation of the bar a is:

$$\Delta x_A = \frac{Pl}{a E_D}.$$

The wire will elongate an amount $\Delta x_C \cos\phi$ and hence:

$$T = \frac{\Delta x_C \cos\phi}{l \sec\phi} \alpha_o E_w.$$

This produces a horizontal pull at C_2:

$$T \cos\phi = \frac{\Delta x_C \cos^3\phi}{l} \alpha_o E_w$$

assisting the c-bar in counteracting P. If we now put:

$$\frac{\Delta x_C \cos^3\phi}{l} \alpha_o E_w = \frac{\Delta x_C}{l} \alpha E_D$$

it is seen that, as far as horizontal pull is concerned, we might replace the wire by a horizontal bar of duralumin of a sectional area α such that

$$\alpha = \frac{E_w}{E_D} \alpha_o \cos^3\phi \tag{1}$$

where the ratio $\frac{E_w}{E_D}$ for duralumin and wire steel has a value of about 2.87.

Substituting this *fictitious bar* for the wire at C_2, we have:

$$T \cos\phi = \frac{\Delta x_C}{l} \alpha E_D$$

$$F_c = \frac{\Delta x_C}{l} a E_D$$

$$P = \frac{\Delta x_C}{l} (a + \alpha) E_D$$

Hence

$$T = \frac{\alpha}{a + \alpha} P \sec\phi \tag{2}$$

$$F_c = \frac{a}{a + \alpha} P \tag{3}$$

These are important equations. They show how the pull at the joint is distributed between the wire and the girder, and, evidently, if several wires are attached to the same joint, they can each of them be represented by a fictitious bar parallel with the girder.

The rule expressed by (2) and (3) is applicable also in ordinary girder construction, where the diagonals may be flat bands of steel plates, angle bars or other profiles, the only condition being that the vertical frames or posts must be rigid and capable of preserving the distance between the girders. It applies in compression as well as in tension, but in case of wires only up to the point where the wires become slack.

If the support at A_2 were removed, the panel would distort, the frame (2) moving upwards until $T = 0$. Under the assumed conditions this does not occur, and we have:

$$T = Q \operatorname{cosec} \phi$$

Case 2. Tensile P-forces and a Q-force act on the panel.—As in Case 1, there is only one wire, and tensile P-forces cause the girders to elongate, but no support is found at A_2 and an independent shearing or Q-force is acting on frame (2), producing a downward deflection. See Figs. 3 and 4, the latter of which shows in detail the deflections of the joint C_2.

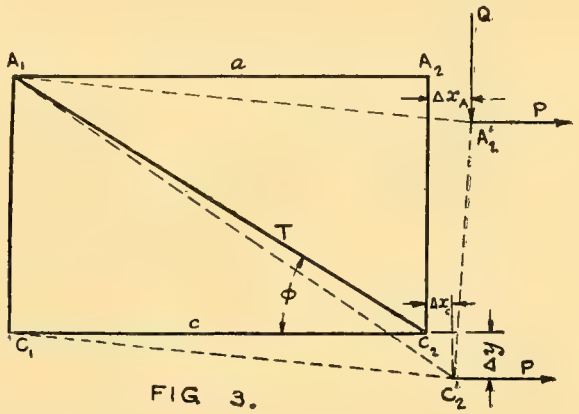


FIG. 3.

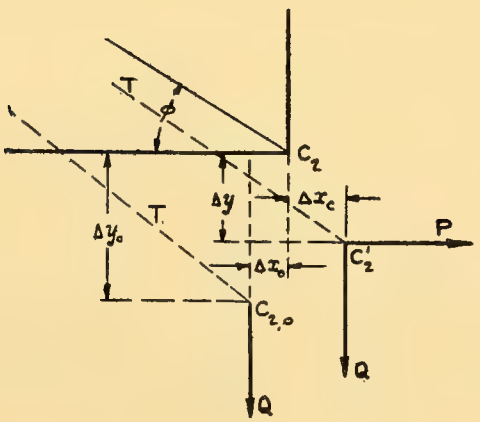


FIG. 4.

We suppose first that only the shearing force is active. Under the action of shearing C_2 goes to $C_{2,0}$ creating a tension T in the wire, a contraction Δx_0 in the c-bar and a vertical deflection Δy_0 in frame (2).

$$T = Q \operatorname{cosec} \phi, \qquad F_a = 0, \qquad F_c = T \cos \phi = Q \cot \phi.$$

$$\Delta x_0 = \frac{F_c l}{a E_D} = -\frac{Q l \cot \phi}{a E_D} \text{ (contraction).}$$

The elongation of the wire is:

$$\Delta y_o \sin \phi + \Delta x_o \cos \phi = \frac{T}{\alpha_o} \frac{l \sec \phi}{E_w}$$

$$\therefore \Delta y_o = \frac{Ql \operatorname{cosec}^2 \phi \quad \sec \phi}{\alpha_o E_w} + \frac{Ql \cot^2 \phi}{a E_D} = \frac{a+\alpha}{\alpha} \frac{Ql \cot^2 \phi}{a E_D} \tag{4}$$

When now the P-forces are applied in addition to the shearing, the panel takes up a new position of equilibrium. The corner $C_{2,0}$ goes to C_2', where the vertical deflection is only Δy and the horizontal deflection is Δx_c. It is here assumed that the elongation of the girders due to P is greater than the contraction due to T, as would usually be the case in an airship when the P-forces are at all considerable. The tension in the wire is to the first order the same as before P was applied, and hence we have again:

Further:

$$\left.\begin{aligned} T &= Q \operatorname{cosec} \phi \\ F_a &= P \\ F_c + T \cos \phi &= P \\ \therefore F_c &= P - Q \cot \phi \end{aligned}\right\} \tag{5}$$

$$\Delta x_A = \frac{Pl}{a E_D}, \qquad \Delta x_C = \frac{(P - Q \cot \phi)\, l}{a E_D}$$

$$\Delta y \sin \phi + \Delta x_C \cos \phi = \frac{Tl \sec \phi}{\alpha_o E_w}$$

$$\therefore \Delta y = \frac{a+\alpha}{\alpha} \frac{Ql \cot \phi}{a E_D} - \frac{Pl \cot \phi}{a E_D} = \Delta y_o - \frac{Pl \cot \phi}{a E_D} \tag{6}$$

It is seen that Δy consists of two parts, one of which depends entirely on Q and is the same as if Q were acting alone, while the other depends only on P and represents the amount which the end of the panel is raised by the action of that force.

The effect of the P-force is the same as if an upwards Q-force Q' existed, counteracting and carrying part of the original force Q. If, then, the P-forces had existed in conjunction with Q' only, there would have been no distortion and hence Q' is the force necessary to balance the upwards tendency, the same as the reaction Q in Case 1.

The deflection produced by Q' acting alone is according to (4):

$$\frac{a+\alpha}{\alpha} \frac{Q' l \cot^2 \phi}{a E_D}$$

and equating this to the vertical deflection recovered by the P-forces according to (6), we get:

$$\frac{a+\alpha}{\alpha} \frac{Q' l \cot^2 \phi}{a E_D} = \frac{Pl \cot \phi}{a E_D}$$

from which:

$$Q' = \frac{\alpha}{a+\alpha} P \tan \phi \tag{7}$$

The corresponding tension in the wire is

$$T' = Q' \operatorname{cosec} \phi = \frac{\alpha}{a + \alpha} P \sec \phi \tag{8}$$

but this is precisely the tension produced in the wire in Case 1. While, therefore, the total tension in the wire is necessarily equal to Q cosec ϕ, it must not be overlooked that, if P-forces exist, part of that tension is virtually due to these forces, which carry a corresponding part of the shearing load.

The end load on the c-girder, which under pure shear would be Q cot ϕ, is now:

$$F_c = P - Q \cot \phi = \frac{a}{a + \alpha} P - (Q - Q') \cot \phi$$

showing that also here the load is made up of two parts, one due to the P-force, which is distributed between the wire and the girder, as if there was no deflection, and another due to the difference in shear between Q and Q'. If only Q' had been acting, that is, $Q = Q'$, we would get

$$F_c' = \frac{a}{a + \alpha} P \tag{8'}$$

If the P-forces acting on A_2 and C_2 had been unequal, we should obtain the same result as far as the c-girder is concerned.

An investigation of the case when the P-forces are compressive gives similar results. The shear force acting alone gives a certain deflection Δy_0, but the P-forces now increase that deflection and at the same time compress the girders. The tension in the wire, however, remains unaltered, and is less than it would be for that deflection if produced by the Q-force acting alone. The effect of the P-forces is now the same as if an additional downwards

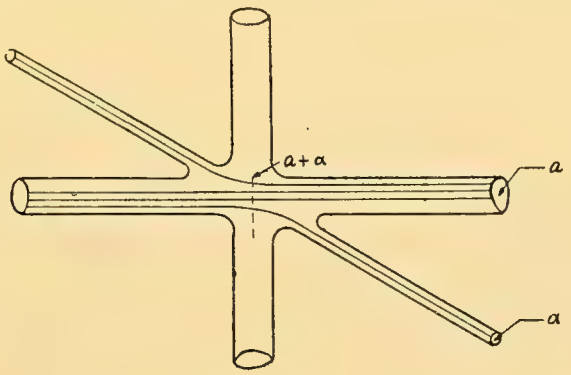


FIG. 5.

shear force Q' were acting, and T as well as F may be regarded as virtually consisting of two parts, one of which is entirely due to P, the other entirely due to Q. This is in accordance with the principle of the superposition of small strains and deflections.

Hence, whether the P-forces are tensile or compressive, we may regard the wire as a channel along which flow stresses, the magnitude of which are proportional to the sectional

area α. Just to the left of the center of the joint C_2, we have a total sectional area equal to $a + \alpha$ through which flows a force P. One part $\frac{a}{a+\alpha} P$ flows along the c-bar and another $\frac{\alpha}{a+\alpha} P$ flows along the fictitious bar which represents the wire, and this is quite irrespective of the Q force (so long as it is great enough to secure the tautness of the wire when the P-forces are compressive). The average stress in the joint C just to the left of the center is $\frac{P}{a+\alpha}$. If the panel is connected to other similar panels, so that a shear wire is running downwards to the right of the joint, we shall reckon the effective area to be $a + \alpha$ to the right of the joint and, hence, also at the center (see Fig. 5).

Case 3.—This study leads to an important case which occurs in airships, where the panels, which are supposed to deflect downwards an amount Δy due to the shear force ΣQ acting on the entire frame, are prevented by adjacent panels from adjusting themselves to the action of the P-forces. Under these conditions internal reactions will be created in the transverse frames, which reactions relative to the panel under consideration may be regarded as external forces.

The reaction Q' at any panel is of such magnitude as just to counterbalance the action of P, which is a tendency to raise or lower the panel. We know from (7) that:

$$Q' = \frac{\alpha}{a + \alpha} P \tan \phi$$

and from (8) that it creates in the wire a force, tensile or compressive:

$$T' = \pm \frac{\alpha}{a + \alpha} P \sec \phi.$$

If Q is the external shearing force, transmitted from the panel next above, the total tension in the wire will be:

$$T = Q \operatorname{cosec} \phi \pm \frac{\alpha}{a + \alpha} P \sec \phi \qquad (9)$$

Hence the tension in the wires will not, as commonly assumed, be that determined by the shearing force alone, but yet the sum of all the vertical components of the T-forces in the frame space will be equal to ΣQ. In other words, the internal reactions in the transverse frame must neutralize each other completely.

In the c-girder the combined effect of P and Q is, under these circumstances:

$$F_c = Q \cot \phi \pm \frac{a}{a + \alpha} P \qquad (10)$$

Case 4. Initial tension in the wires.—Only panels with two diagonal wires need to be considered, since initial tension cannot exist in a single wire when the panel is held at one frame only.

We go at once to the general case when tensile or compressive P-forces act in conjunc-

tion with a shearing force Q (see Fig. 6). The wires are supposed to be under an initial tension T_0 and the elongations or contractions of the girders, reckoned from the initial inert condition, before the wires were tightened, are Δx_0, Δx_A, and Δx_C.

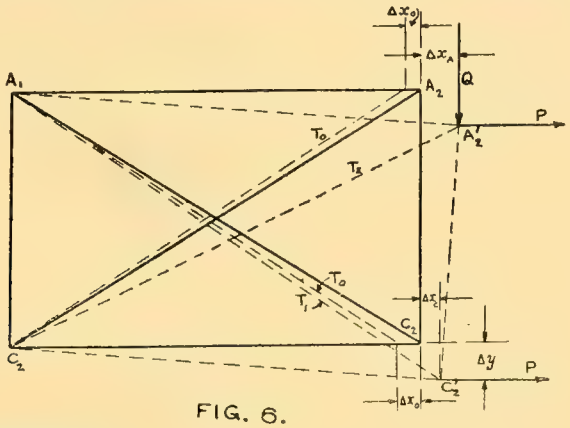


FIG. 6.

We have for both girders:

$$F_0 = T_0 \cos \phi \tag{11}$$

$$\Delta x_0 = \frac{T_0 l \cos \phi}{a E_D} \tag{12}$$

Suppose first that the P-forces are tensile. The fundamental equations are:

$$\left.\begin{aligned} F_a + T_2 \cos \phi &= P \\ F_c + T_1 \cos \phi &= P \end{aligned}\right\} \tag{13}$$

$$T_1 - T_2 = Q \operatorname{cosec} \phi \tag{14}$$

The difference between the tension in the wires is such as to just balance the vertical shearing force.

$$\left.\begin{aligned} \Delta x_0 + \Delta x_C &= \frac{T_0 l \cos \phi + F_c l}{a E_D} \\ \Delta x_0 + \Delta x_A &= \frac{T_0 l \cos \phi + F_a l}{a E_D} \end{aligned}\right\} \tag{15}$$

$$\left.\begin{aligned} T_1 &= T_0 + \frac{[(\Delta x_0 + \Delta x_C) \cos \phi + \Delta y \sin \phi]}{l \sec \phi} E_w \alpha_0 \\ T_2 &= T_0 + \frac{[(\Delta x_0 + \Delta x_A) \cos \phi - \Delta y \sin \phi]}{l \sec \phi} E_w \alpha_0 \end{aligned}\right\} \tag{16}$$

From equations (12) to (16):

$$T_1 = T_0 + \frac{\alpha}{a + \alpha} P \sec \phi + \tfrac{1}{2} Q \operatorname{cosec} \phi \tag{17}$$

$$T_2 = T_0 + \frac{\alpha}{a + \alpha} P \sec \phi - \tfrac{1}{2} Q \operatorname{cosec} \phi \tag{18}$$

$$F_a = \frac{a}{a + \alpha} P - T \cos \phi + \tfrac{1}{2} Q \cot \phi \tag{19}$$

$$F_c = \frac{a}{a + \alpha} P - T \cos \phi - \tfrac{1}{2} Q \cot \phi \tag{20}$$

The total elongations from the initially strained conditions as well as the vertical deflections are found to be in amount the same as if no initial tension had existed, and hence the rigidity is the same.

Due to the initial tension the stress in the bars is reduced by an amount $\frac{T_0 \cos\phi}{a}$, but the stress in the wires is increased by an amount $\frac{T_0}{a_0}$.

It is seen that the tension in the wires is due to three causes: first, the initial tension T_0; second, the pull P; third, the shearing force Q. The second of these varies directly as the effective sectional area of the wire. The heavier the wires, the greater the share which they take of the longitudinal pull.

The vertical deflection is

$$\Delta y = \frac{a + \alpha}{\alpha} \frac{Q l \cot^2 \phi}{2 a E_D} \tag{21}$$

which is the same as if no initial tension existed, but only one-half of its value in a single-wire panel.

When the P-forces are compressive, the formulas given for tensile forces hold good when the sign of the P and F-forces are changed.

The vertical deflection is the same as when the panel is in tension (21) and much less than if there had been no initial tension in the wires. Hence the rigidity under shearing is greatly increased.

Since the elongation of the wires caused by initial tension is much greater than the corresponding contraction in the girders, even a moderate tension in the wires is sufficient to prevent them from becoming slack within the limit of the safe working stress in the girders. Under great shearing, however, the counterwire may become slack, but the stresses in the girders and in the wires are the same as in a single-wire panel.

Thus the strength of the frames under these conditions is not affected by the initial tension in the wires, but the rigidity is increased.

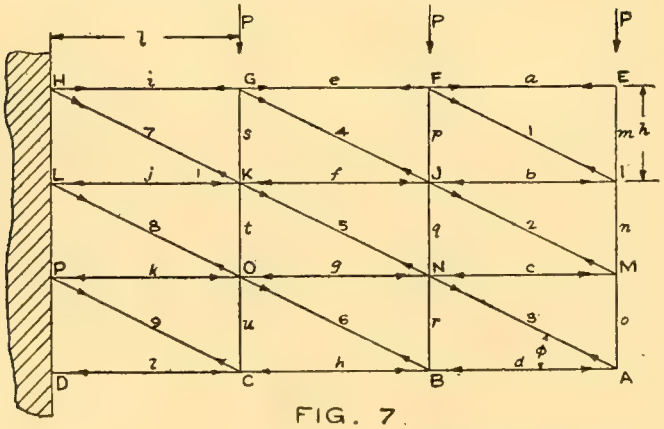


FIG. 7.

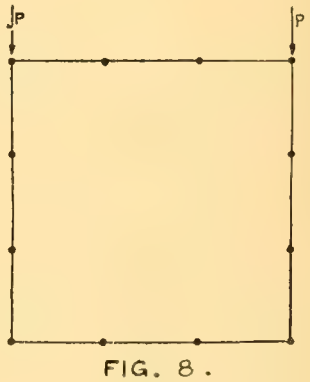


FIG. 8.

IV. A COMPOUND N-GIRDER.

Space does not allow a complete discussion of this case, but as it forms an important link in the investigation of the relative merits of the bending and shearing method, it is necessary to state the main results. The design of the girder is shown in Fig. 7; it is practically all

web and is loaded in its own plane. It is assumed that lateral bending is prevented without affecting the stresses. According to the shear method there should be no longitudinal forces acting at the joints of the two middle girders, but between the joint compressive forces are produced locally by the tension in the wires. The upper girder as a whole would be in tension, the lower in compression. Clearly such a girder, under the loading indicated, would bend, and the middle girders would take actually their share of the general strains.

If four girders such as that in Fig. 7 are combined to form a box-girder of square section as indicated in Fig. 8, and if each of the side girders are put under the same load as in Fig. 7, it is found according to the shear method that only the four corner girders should be active, none of the other girders would assist in carrying the load, except in so far as they would act as local struts for the wires. Again, this cannot be correct. If the top and bottom girders are provided with a system of double diagonal wires set up with initial tension, the middle girders will evidently form an integral part of the flanges of the box girder and must come under a general longitudinal strain in bending. In fact, the failure of the shear method is brought out as soon as it is applied to the horizontal flanges of a structure, where horizontal shearing transmits longitudinal strains from one girder to the other.

It was attempted for the purpose of comparison to determine the internal reactions in the compound N-girder in an exact manner by the Principle of Least Work as well as by the Method of Deflections, but these methods, even in this simple case, led to a great number of cumbrous equations, involving determinants of such formidable proportions that a solution in this way seemed impracticable.

V. THE EFFECTS OF SHEARING AND BENDING IN THE STRUCTURE OF AN AIRSHIP.

We consider here an airship of regular polygonal section which is entirely symmetrical about a horizontal plane through the axis and in general construction similar to L-49. The wires are supposed to be initially just taut.

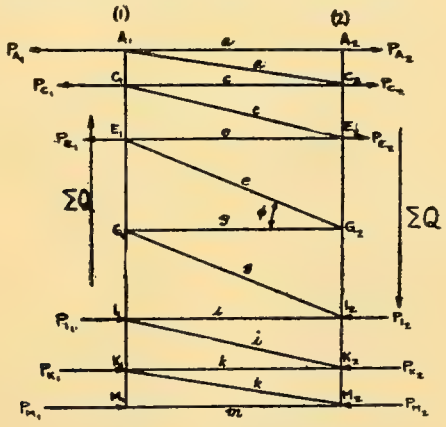


FIG. 9.

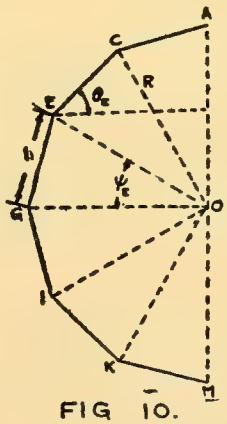


FIG 10.

It is proposed to distinguish sharply between the effects of shearing and bending, and it is assumed that the stresses and strains which they produce can be superposed on one another. Shearing may exist in vertical, horizontal, or other planes, but for the present we shall deal only with shearing forces directed vertically in transverse planes, and to fix our ideas we consider in particular the shearing and bending actions in the forebody of a ship in hogging condition.

We assume first that the ship is subject to pure shearing, producing a system of internal reactions and certain strains and stresses throughout the structure, and to the ship in this fictitious condition we apply the bending moments which would actually be called forth by the shearing. Each frame space may be regarded as typical of the whole structure and may be dealt with separately.

We consider a section of an airship enclosed between two frames (1) and (2) and assume first that frame (1) is held fixed in a vertical position, while (2) is free to deflect (see Figs. 9 and 10).

A. The Effects of Shearing.

A system of vertical forces ΣQ acts on frame (2) tending to deflect it downwards relative to (1). We assume that no external forces act between (2) and (1), but that a similar system of forces ΣQ acts upwards at frame (1), constituting with that on frame (2) what may be called a shearing couple. The shear wires come in tension, the counterwires become slack, and the lower girder in each panel comes under compression. The result is that the wire and the lower girder in each panel together form, as it were, a cantilever loaded at the extreme end with a Q-force. The wire exerts a pull at a joint in frame (1), having a horizontal component which is exactly equal to the horizontal thrust exerted by the girder at the joint next below. Together the two forces constitute a couple, which balance the moment Ql and which, when combined with other similar couples, generally of different magnitude, produced by the cantilevers in the other panels, form an aggregate bending moment ΔM, acting on frame (1). Hence

$$\Delta M = \Sigma Ql \tag{22}$$

where l is the frame spacing.

We shall now show how to find the stresses in the girders and the wires and further, that under the special conditions of symmetry existing in this case, the total reactions at the joints in (1) will have horizontal components P, which together constitute a system of forces conforming to the theory of bending, *i. e.*, they are proportional to the distances of the joints from the neutral axis.

We use the same notation as in previous chapters and add suffixes as necessary, conforming to Figs. 9 and 10.

In any one panel we have the tension in the wire,

$$T = \frac{\Delta y \sin \phi \sin \theta - \Delta x \cos \phi}{l \sec \phi} E_w \alpha_o \tag{23}$$

where θ is the angle which the panel forms with the horizon. This equation is obtained from that for the elongation of the wire given under Section III, Case 2, for pure shearing (just previous to equation (4)), bearing in mind that a vertical deflection Δy causes a downward deflection $\Delta y \sin \theta$ in the plane of the panel.

The compressive force acting on the lower girder of the panel is:

$$F = T \cos \phi \tag{24}$$

The contraction of that girder is:

$$\Delta x = \frac{Fl}{a E_D} = \frac{T l \cos \phi}{a E_D} \tag{25}$$

$$\therefore\ T = \Delta y \frac{a\,\alpha}{a+\alpha} \frac{E_D}{l} \sin \phi \sec^2 \phi \sin \theta \tag{26}$$

Since the total shearing force must be equal to the sum of the vertical components of the tension in the wires, we have:

$$\Sigma Q = \Sigma T \sin \phi \sin \theta \tag{27}$$

$$\therefore\ \Sigma Q = \Delta y \frac{E_D}{l} \sum \frac{a\,\alpha}{a+\alpha} \tan^2 \phi \sin^2 \theta \tag{28}$$

where the Σ sign comprises all the panels on both sides of the ship. Substituting the value of Δy as determined by (28), in (26) we obtain:

$$T = \frac{a\,\alpha}{a+\alpha} \frac{\sin \phi \sec^2 \phi \sin \theta\ \Sigma Q}{\sum \frac{a\,\alpha}{a+\alpha} \tan^2 \phi \sin^2 \theta} \tag{29}$$

When the section of the ship is a regular polygon as here assumed, the angle ϕ is constant and we get:

$$T = \frac{a\,\alpha}{a+\alpha} \frac{\operatorname{cosec} \phi \sin \theta\ \Sigma Q}{\sum \frac{a\,\alpha}{a+\alpha} \sin^2 \theta} \tag{29'}$$

If, moreover, a and α are the same in all the panels, we get:

$$T = \frac{\operatorname{cosec} \phi \sin \theta\ \Sigma Q}{\Sigma \sin^2 \theta} \tag{29''}$$

The expressions (29) and (29′) differ somewhat from that usually given, because ordinarily no account is taken of Δx, the contraction of the girders. In fact, the usual formula as given for a ship with equidistant longitudinals but varying sectional area of the wires is:

$$T = \frac{\alpha_o \operatorname{cosec} \phi \sin \theta\ \Sigma Q}{\Sigma \alpha_o \sin^2 \theta} \tag{29'''}$$

We assume here that the conditions underlying (29″) hold good, in which case, since ϕ, ΣQ, and $\Sigma \sin^2 \theta$ are constant for the given section, T is proportional to $\sin \theta$. The compression in the girders is found by multiplying the expression for T with $\cos \phi$. From (29″) we obtain:

$$F = \frac{\cot \phi \sin \theta\ \Sigma Q}{\Sigma \sin^2 \theta} \tag{30}$$

which, again, is proportional to $\sin \theta$. It must be noted that θ is the inclination to the horizon of the panel of which the girder in question forms the lower boundary.

Consider now two panels n and $n+1$, the lower girders of which are called n and $n+1$. Let ψ be the angle, which the radius from the center, O, of a frame to a girder forms with the horizon, and x the angle which the sides of the panels subtend at the center (see Fig. 11).

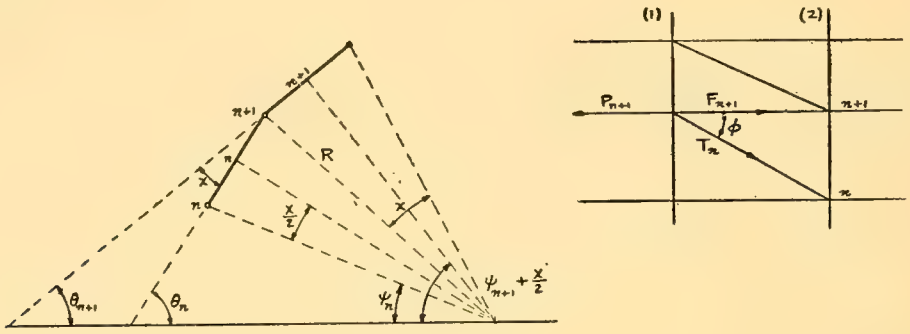


FIG. 11.

We have:

$$P_{n+1} = F_{n+1} + T_n \cos \phi \tag{30'}$$

where F_{n+1} and T_n are given by (30) and (29″).
Let:

$$T_n = K \sin \theta_n$$

$$F_{n+1} = -K \sin \theta_{n+1} \cos \phi.$$

Where $K = \dfrac{\operatorname{cosec} \phi \ \Sigma Q}{\Sigma \sin^2 \theta}$ is independent of variations in ψ and θ.

Further:

$$\theta_n = \theta_{n+1} + x \text{ and } \psi_{n+1} + \frac{x}{2} = \frac{\pi}{2} - \theta_{n+1}$$

$$\theta_n = \frac{\pi}{2} - (\psi_{n+1} - \frac{x}{2}).$$

$$P_{n+1} \propto \left[\sin \theta_n - \sin \theta_{n+1} \right] \propto \left[\cos (\psi_{n+1} - \frac{x}{2}) - \cos (\psi_{n+1} + \frac{x}{2}) \right] \propto \sin \psi_{n+1}) \sin \frac{x}{2}$$

and since x is constant we have:

$$P_{n+1} \propto \sin \psi_{n+1} \tag{31}$$

that is, the P-force is proportional to sin ψ and hence to the distance of the girder from the neutral axis, but it must be borne in mind that if the longitudinals were spaced irregularly or if a and α_0 varied, P_{n+1} would not follow this law.

The result here obtained is important, because it follows that a shearing force acting at any frame produces in the next frame a system of P-forces which in the ideal structure here under consideration is in full accord with the theory of bending.

B. The Effects of Bending.

Suppose next that a pure bending moment, M_2, is applied to frame (2) and that its effects are superposed on those due to the shearing force ΣQ. It is assumed that the P-forces constituting M_2 are applied in accordance with the theory of bending, and we have then to study their transmission through the section (2)-(1).

All the panels between (1) and (2) take the same downward deflection under the action of ΣQ, but when the P-forces are applied, the panels will tend to lift in the upper part of the ship and to drop in the lower part. This tendency creates reactions in frame (2), which comes under tension, but since the upward forces are equal to the downward forces, the panels will be unable to deflect either up or down. Under these circumstances, as given by equation (9), the tension in the wires above the neutral axis will be increased beyond that existing under pure shearing by the amount T', while that in the wires below the neutral axis will be reduced below that standard by the same amount, but the total sum of the vertical components of the tensions will be equal to the sum of the shearing forces.

$$\Sigma\ T \sin\phi \sin\theta = \Sigma Q.$$

So also F is increased or reduced in each panel by an amount F' as compared with its value due to Q.

Hence (see Section III, Case 3) a force T' is transmitted to the wire meeting at any joint on frame (2):

$$T' = \frac{\alpha}{a+\alpha} P \sec\phi$$

while a force:

$$F' = \frac{a}{a+\alpha} P$$

will be directed along the girder.

These forces superpose themselves on those due to shearing and, using (29″) and (30), we obtain:

$$\left.\begin{aligned} T &= \frac{\operatorname{cosec}\phi \sin\theta\ \Sigma Q}{\Sigma \sin^2\theta} \pm \frac{\alpha}{a+\alpha} P \sec\phi \\ F &= \frac{\cot\phi \sin\theta\ \Sigma Q}{\Sigma \sin^2\theta} \pm \frac{a}{a+\alpha} P \end{aligned}\right\} \qquad (32)$$

It is believed that the facts expressed by these equations have not before been explained or pointed out, but they are evidently of great importance for the full understanding of the reactions in complex wired structures such as airships. The principal facts are that shear wires, when in tension, act as elastic struts capable of transmitting both tension and compression; that their tension, when the panel is under shearing, is not always determined exclusively by the shearing force; and that, even when so determined, the tension is virtually in part due to the direct pull or thrust acting on the longitudinals. Hence the shear wires, except when they are slack, should be considered as an integral part of the longitudinal strength members of the hull.

VI. APPLICABILITY OF THE THEORY OF BENDING TO AN ACTUAL AIRSHIP.

We have hitherto dealt chiefly with airships of ideal section, where the shearing force at one frame initiates a system of P-forces in the adjacent frame conforming to the bending theory. It appeared, as far as the investigation went, that in such a structure the theory applies at least as well as in an ordinary ship. Actually airship structures deviate somewhat from the ideal form. The sections are not always of a regular polygonal form throughout, the longitudinals and the wires may not be of uniform strength, and the keel structure is much heavier than the top structure. It is desirable, therefore, to inquire into the fundamental assumptions underlying the bending formula:

$$\frac{M}{I} = \frac{P}{y} \tag{33}$$

so as to ascertain whether or not an airship possesses features that seriously impair its validity.

The fundamental assumptions in the established theory of bending of a beam are :

1. That the beam is homogeneous, of uniform transverse section, and perfectly elastic.
2. That sections plane before bending are plane after bending.
3. That longitudinal layers of the beam expand and contract laterally in the same way as if they were disconnected from each other.

It has been proved by theory and experience that these assumptions can be departed from to some extent without invalidating the theory. It is found that, if the material is homogeneous and perfectly elastic, the theory applies even though the transverse sections vary, provided they vary in a continuous manner. It applies to curved as well as to straight beams even although the curvature varies, provided it varies in a continuous manner. At sections where great discontinuity exists, either in section or curvature, the theory does not apply. The way in which the bending couple is applied does not sensibly influence the distribution of the stresses except locally in the nearest vicinity of the sections where the forces are applied. The plane of the bending couples need not be a principal plane of the beam.

Assuming that the wires are set up with an initial tension and that hence, in general, both shear and counterwires are active, we shall now examine in how far the assumptions stated above hold good in an airship.

As regards the first assumption, the sections in an airship vary in a strictly continuous manner, more so than in ordinary ships, where the continuity is often broken by a forecastle, a poop and by deckhouses. Each section approaches in form to that of a regular many-sided polygon, while in a ship a great discontinuity in form occurs at the deck edges. In a general way rigid airships are also of a more homogeneous construction than ordinary ships provided the wiring is fairly uniform or proportional to the girders; they are also perfectly elastic. Now, in spite of the deviations from the fundamental assumptions in ordinary ships, the theory has been found to give a fairly close approximation to observed data in cases where measurements of strains and deflections have been made, and it is generally accepted by naval architects as an established fact that the method is reliable as a means of comparison between ships of not too different type. It appears, therefore, that the requirements of the first assumption are complied with in a satisfactory manner.

The second assumption probably holds good under pure bending, where the deflections are entirely due to elongation and compression of the longitudinals, since the deviations of these strains from the requirements of the theory are extremely small in relation to the

linear dimensions of the transverse sections. The shearing deflections, on the other hand, are extraordinarily great, and it is in this respect that an airship structure differs most radically in behavior from all other girders, including the hull of ordinary ships. It might be argued that the shearing deflections cause a distortion of the sections out of their plane, thus invalidating the theory. It appears, however, that we are justified in considering the strains due to shearing quite independent of those due to bending and in such case we may apply the bending theory, not only to the ship in its original unstrained condition, but also when it is distorted by pure shearing. It may then, in fact, be regarded as a slightly curved girder.

We assume, then, that due to pure shearing the transverse frames are displaced vertically relative to each other, transforming the fair contour lines of the profile to more or less wavy lines. To every hump in the upper contour corresponds an upward hollow of the same height in the lower contour. The longitudinals, in order to accommodate themselves to these deflections, must all bend together; deflecting upwards or downwards by the same amount in each section, remaining parallel to one another in the parallel middle body. On account of their slenderness, the longitudinals can easily bend to the required gentle curves without suffering any appreciable general strain. For instance, a deflection of about 3 feet amidships in one of the main longitudinals of L-49, supposed to be loaded uniformly and supported at the ends, would cause a stress in the upper channel of the girder of only about one-quarter of a ton per square inch. Hence it appears that we are justified in disregarding the general strains in the longitudinals due to the shearing deflection, and that we may consider the ship in that condition as a slightly curved beam to which, as stated above, the theory is applicable. The strains due to bending are simply superposed on those due to shearing.

It remains, however, to consider the secondary strains created in the longitudinals at the joints with the transverse frames, because at these points there is a certain encastrement, which will offer some resistance to the bending of the longitudinals relative to the plane of the transverse frames. The result will be a bending moment at each frame, a local deflection of the frames out of their plane combinedwith twisting and bending, and instead of the continuous curvature of the longitudinals over the joints there will be a stepwise curvature with points of inflection between the frames (see Fig. 12). The local bending and shearing strains so produced will cause additional stresses and a certain resistance to the general shearing deflections of the ship and should be taken into account in calculating the total stresses, but they do not affect the applicability of the bending theory.

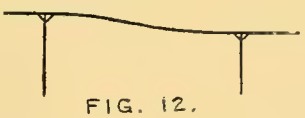


FIG. 12.

The third assumption enumerated above is generally considered to be justified in all except very broad beams. Since airships are of nearly circular section, the assumption may here be accepted.

On the whole, then, we conclude that the bending method can be safely applied with a fair degree of approximation to airships as now usually constructed.

The most serious deviation from uniformity of strength in airships as commonly constructed seems to be the reduction in the size of the wires in the upper and lower part of the hull. This causes an irregular distribution of the stresses and prevents certain girders from

doing their full share in accordance with the theory of bending. Although there will always be a tendency towards a redistribution of the forces conforming to that theory, this may not be fully accomplished due to the relatively small number of frame spaces in an airship. The discrepancy may be discovered by comparing the horizontal shear at any girder as determined by the bending method with that actually produced by the tension of the shear wires.

VII. MODE OF CALCULATION.

We shall now show more in detail how to use the bending method. The fundamental equation, (33), applies to sections at the frames through the center of the joints, where, under certain assumptions, the stresses may be expected to be the same as in an ordinary plated structure of the same strength. Between the frames the stress in the longitudinals may be affected by the tension of the wires if the counterwires are slack, and does not then follow the law of proportionality to the distance from the neutral axis. The bending formula, therefore, cannot under all circumstances give the stresses in the strength members existing between the frames, but having determined the stresses at the joints, we can calculate the horizontal reactions, here called the P-forces, at these points and then, by resolving along longitudinals and wires, the stresses in these members can be found.

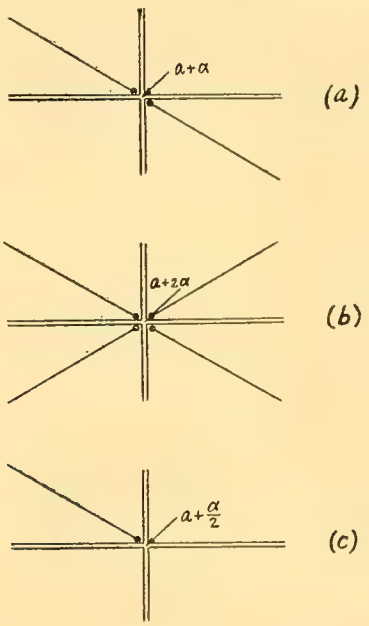


FIG. 13.

Before applying formula (33) it is necessary to determine the effective area of the longitudinal strength members at the joints. The lines of force flow along longitudinals and diagonal wires through the joints, and we assume that these latter are so constructed that their transverse sectional area is equal to the sum of the areas of the longitudinal members meeting at the joint. Since we need consider only the P-forces, we can replace the diagonal wires by fictitious bars of duralumin, the area of which is denoted by α as explained in Section III, Case 1. Suppose that a longitudinal passes through a joint and that a shear wire is attached to the joint on either side as in Fig. 13 (a), then the longitudinal strain in

the members on either side of the joint is the same as would exist in a bar of the sectional area $a + \alpha$ under the action of P.

Where both the shear wires and the counterwires are taut and where they are fitted symmetrically on both sides of a joint, as indicated in Fig. 13 (b), the effective area is $a + 2\alpha$.

Where a diagonal wire is found on one side of a joint and not on the other, the aggregate elongation of the longitudinal reckoned between half-frame stations just forward and aft of the joint is approximately the same as if the girder had an area $a + \frac{\alpha}{2}$, whence this is reckoned to be the effective area at the joint (Fig. 13 (c)).

This method applies to all wires so long as they are taut, whether the tension is increased as by a pull P or reduced as by a thrust P. It is strictly correct where the two longitudinals that are connected by a wire are subject to the same P-force, since in that case the horizontal pull exerted by either end of the wire is actually $p\alpha = T \cos \phi$, where p is the stress at the joint. But in an airship, subject to bending, the stresses at the joints are proportional to y, the distance from the neutral axis. If now we reckon the equivalent area to be equal to α at either end, we shall have a different total tension at the ends of the wire, which is impossible. We must, therefore, introduce a modification of the equivalent area.

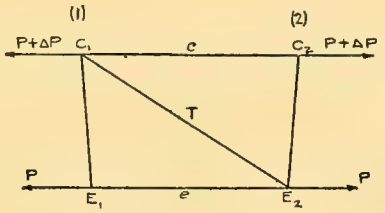


FIG. 14.

Referring to Fig. 14, consider a panel between two frames (1) and (2) and two longitudinals c and e. Under pure bending the stresses, assumed to be tensile, at the joints are p_C at C_1 and C_2 and p_E at E_1 and E_2. The distances of the joints from the neutral axis are y_C and y_E respectively and let

$$\frac{y_C + y_E}{2} = y_{CE}.$$

The tension in the shear wire is T, which is determined by the mean extension of the longitudinal bars. We may, therefore, substitute for T a fictitious horizontal bar of area α midway between the longitudinals, in which case we obtain the correct pull exerted by the bar, αp, where

$$p = \frac{y_{CE} M}{I} \tag{34}$$

In reality the pull acts at C_1 and E_2, and it is not strictly correct, as proposed by some, to place α midway between the C and E girders in calculating the moment of inertia unless both shear and counterwires are active. It is desirable, when the counterwire is slack, to substitute for α a value α_C at C_1 such that

$$\alpha_C p_C y_C = \alpha p y_C \text{ or } \alpha_C = \frac{p}{p_C}\alpha$$

where p is determined by (34), but since $\frac{p}{p_C} = \frac{y_{CE}}{y_C}$ we find $\alpha_C = \frac{y_{CE}}{y_C}\alpha$.
Similarly

$$\alpha_E = \frac{y_{CE}}{y_{CE}}\alpha$$

or, in general, for a wire between the longitudinals n and $n+1$:

$$\alpha_n = \frac{y_{n(n+1)}}{y_n}\alpha \tag{35}$$

where $\alpha = \alpha_0 \frac{E_w}{E_D}\cos^3\phi$.

Hence, by multiplying α with the y-ordinate of a point midway between the joint which the wire connects and dividing by the y-ordinate of the joint considered we obtain the equivalent effective area for the wire at that joint. The rule evidently applies to counterwires and shear wires alike and whether they are in compression or tension. Where a girder is located in the neutral axis, (35) gives $\alpha_n = \infty$, but since the y-ordinate and the P-forces are zero in this case, the moment of inertia and the distribution of the forces are not thereby affected. In order to determine the exact location of the neutral axis, some tentative figuring may be necessary.

It is recommended to apply this method of evaluating the effective area α whenever the counterwires are slack. If all wires are taut, the fictitious bars may be placed midway between the longitudinals as explained above.

We are now able to compute the moment of inertia at any frame section and can then from (33) with the given bending moment find the stresses and the P-forces at the various joints. After that the stresses in each one of the members adjacent to the frame under consideration can be determined by resolving the P-forces along these members and finally the forces due to shearing are superposed.

In order to illustrate the method we shall apply it to a frame space of an airship and choose for the sake of simplicity that of the symmetrical ship referred to above and given in Figs. 9 and 10, assuming that a bending moment M_2 and a shearing force ΣQ are applied to frame (2). The calculation is typical for any frame space that we wish to consider.

It is supposed that all the wires are set up with an initial tension T_0 and that no counterwires become slack. Hence the effective area of each joint is $a + 2\alpha$, but the correction according to (35) is here applied to α at each joint in order to illustrate the method.

The ordinates of the various joints are found by multiplying R, the radius of the ship, with the sine of angle ψ, which the radius to any longitudinal forms with the horizon:

$$y_A = R, \quad y_C = y_K = R \sin 60^\circ = .866\ R$$
$$y_E = y_I = R \sin 30^\circ = .500\ R, \quad y_G = 0.$$

The ordinates of the middle of the wires are:

$$y_{AC} = -y_{KM} = .933\ R, \quad y_{EC} = -y_{IK} = .683\ R, \quad y_{GE} = -y_{GI} = .250\ R.$$

From (35):

$$\alpha_A = \alpha_M = \frac{y_{AC}\alpha}{y_A} = .933\ \alpha.$$

For the other joints we must, in calculating the moment of inertia, take the mean value for each set of shear wires or counterwires meeting at each joint, one belonging to a panel above and the other to a panel below the joint. For instance, at C_2 we find a shear wire a to the left with an area:

$$\alpha_{CA} = \frac{y_{AC}}{y_C}\,\alpha = \frac{.933}{.866}\,\alpha$$

and a shear wire c_2 to the right with an area

$$\alpha_{CE} = \frac{y_{CE}\alpha}{y_C} = \frac{.683}{.866}\,\alpha.$$

The mean value of these is:

$$\alpha_{C_1} = \frac{1.616}{2 \times 866}\,\alpha = .933\ \alpha.$$

For the counterwires meeting at C_2 we find likewise $\alpha_{C_2} = .933\ \alpha$.

Now it is found that in the symmetrical ship here under consideration all the so corrected α values become $.933\ \alpha$, but we shall for the sake of simplicity retain the notation α in the following calculations, bearing in mind that actually in this case

$$\alpha = .933\,\frac{E_w}{E_D}\,\alpha_0 \cos^3 \phi.$$

Since all the joints have the same effective area, the geometrical neutral axis of the section must pass through the axis of the ship on the level of the G-girder.

The moment of inertia is:

$$I = 6\ R^2\ (a + 2\ \alpha).$$

Apply now a bending moment M_2 to section (2) and find the stresses at the joints by the theory of bending.

$$p_A = -p_M = \frac{M_2 R}{I}, \qquad p_C = -p_K = \frac{M_2 .866\ R}{I} = .866\ p_A$$

so also

$$p_E = -p_I = .500\ p_A, \qquad p_G = 0.$$

The horizontal or P-forces acting at the joints of (2) are:

$$P_A = -\ P_M = p_A\ (a + 2\ \alpha)$$

which we shall denote by P for convenience.

The remaining forces are:

$$P_C = -\ P_K = .866\ P, \qquad P_E = -P_I = .500\ P, \qquad P_G = 0.$$

The P-forces are transmitted to frame (1) through the wires and longitudinals between (1) and (2), in which members they call forth the following forces:

$$
\left.\begin{aligned}
T'_{a2} &= -T'_{k1} = \tfrac{1}{2}\frac{\alpha}{a+2\alpha}P\sec\phi \\
T'_{a1} &= T'_{c2} = -T'_{i1} = -T'_{k2} = \tfrac{1}{2}\times .866\,\frac{\alpha}{a+2\alpha}P\sec\phi \\
T'_{c1} &= T'_{e2} = -T'_{g1} = -T'_{i2} = \tfrac{1}{2}\times .500\,\frac{\alpha}{a+2\alpha}P\sec\phi \\
T'_{e1} &= T'_{g2} = 0 \\
F'_{a} &= -F'_{m} = \frac{a}{a+2\alpha}P \\
F'_{c} &= -F'_{k} = .866\,\frac{a}{a+2\alpha}P \\
F'_{e} &= -F'_{i} = .500\,\frac{a}{a+2\alpha}P \\
F'_{g} &= 0
\end{aligned}\right\} \qquad (36)
$$

The suffix (1) is used for the shear wires, the suffix (2) for the counterwires.

At the same time the shearing force ΣQ acting on frame (2) will cause tensions in the wires and end loads on the girders.

The angles which the panels make with the horizon are:

$$
\begin{aligned}
\theta_a = \theta_k &= 15^\circ, \qquad \sin\theta_a = .259 \\
\theta_c = \theta_i &= 45^\circ, \qquad \sin\theta_c = .707 \\
\theta_e = \theta_g &= 75^\circ, \qquad \sin\theta_e = .966
\end{aligned}
$$

$$
\therefore\ \Sigma\sin^2\theta = 4\,(\sin^2\theta_a + \sin^2\theta_c + \sin^2\theta_e) = 6.0
$$

By substitution in (29″) and (30) we find:

$$
\left.\begin{aligned}
T_{a1} &= -T_{a2} = T_{k1} = -T_{k2} = \tfrac{1}{2}\times .043\ \mathrm{cosec}\,\phi\,\Sigma Q \\
T_{c1} &= -T_{c2} = T_{i1} = -T_{i2} = \tfrac{1}{2}\times .118\ \mathrm{cosec}\,\phi\,\Sigma Q \\
T_{e1} &= -T_{e2} = T_{g1} = -T_{g2} = \tfrac{1}{2}\times .161\ \mathrm{cosec}\,\phi\,\Sigma Q \\
F_{a} &= -F_{m} = \tfrac{1}{2}\times .086\ \cot\phi\,\Sigma Q \\
F_{c} &= -F_{k} = \tfrac{1}{2}\times .075\ \cot\phi\,\Sigma Q \\
F_{e} &= -F_{i} = \tfrac{1}{2}\times .043\ \cot\phi\,\Sigma Q \\
F_{g} &= 0
\end{aligned}\right\} \qquad (37)
$$

Combine now the effects of bending and shearing and let:

$$
\tfrac{1}{2}\ \mathrm{cosec}\,\phi\,\Sigma Q = \overline{Q}, \qquad \tfrac{1}{2}\frac{\alpha}{a+2\alpha}P\sec\phi = \overline{P}
$$

Then the tensions in the wires after addition of the initial tension are found to be:

$$\left.\begin{aligned}
T_{a1} &= T_0 + .043\,\overline{Q} + .866\,\overline{P}\\
T_{a2} &= T_0 - .043\,\overline{Q} + \overline{P}\\
T_{c1} &= T_0 + .118\,\overline{Q} + .500\,\overline{P}\\
T_{c2} &= T_0 - .118\,\overline{Q} + .866\,\overline{P}\\
T_{e1} &= T_0 + .161\,\overline{Q}\\
T_{e2} &= T_0 - .161\,\overline{Q} + .500\,\overline{P}\\
T_{g1} &= T_0 + .161\,\overline{Q} - .500\,\overline{P}\\
T_{g2} &= T_0 - .161\,\overline{Q}\\
T_{i1} &= T_0 + .118\,\overline{Q} - .866\,\overline{P}\\
T_{i2} &= T_0 - .118\,\overline{Q} - .500\,\overline{P}\\
T_{k1} &= T_0 + .043\,\overline{Q} - \overline{P}\\
T_{k2} &= T_0 - .043\,\overline{Q} - .866\,\overline{P}
\end{aligned}\right\} \qquad (38)$$

The end-loads on the longitudinals are:

$$\left.\begin{aligned}
F_a &= \frac{a}{a+2\alpha}P + .086\cos\phi\,\overline{Q} - 2\,T_0\cos\phi\\
F_c &= .866\,\frac{a}{a+2\alpha}P + .075\cos\phi\,\overline{Q} - 2\,T_0\cos\phi\\
F_e &= .500\,\frac{a}{a+2\alpha}P + .043\cos\phi\,\overline{Q} - 2\,T_0\cos\phi\\
F_g &= -2\,T_0\cos\phi\\
F_i &= -.500\,\frac{a}{a+2\alpha}P - .043\cos\phi\,\overline{Q} - 2\,T_0\cos\phi\\
F_k &= -.866\,\frac{a}{a+2\alpha}P - .075\cos\phi\,\overline{Q} - 2\,T_0\cos\phi\\
F_m &= -\frac{a}{a+2\alpha}P - .086\cos\phi\,\overline{Q} - 2\,T_0\cos\phi
\end{aligned}\right\} \qquad (39)$$

Computing the P-forces as in (30′) for frame (1) and (38) and (39), it is found that they correspond perfectly with the theory of bending.

VIII. THE FAILURE OF THE METHOD OF TRANSVERSE SHEARS.

Much confusion has existed and probably still exists as to the comparative merits of the bending method and the shear method. This confusion has its origin in the fact that airships are usually of a section approaching in form to a regular polygon and the strength of wires and girders is fairly regularly distributed, under which circumstances the method of

shear happens to give stresses which conform to the theory of bending (see equation (31)). The faith in the shear method was confirmed by calculations and experiments, which appear to be mostly carried out on idealized structures, where regularity in form and uniformity in the strength of girders and wires were observed. Thus the shear method came to be generally considered equivalent to the bending method and was by some even considered superior to it. The correspondence between the results obtained by the two methods under those particular circumstances was misinterpreted, being understood to mean that the bending method could be applied only to girders of such ideal construction,* while the shear method applied to girders of any construction. It is easy to show that the correct interpretation is just the opposite. While the bending method gives in general a good approximation, the shear method is incomplete and faulty except in one particular, ideal case.

In Section IV brief reference was made to a "compound N-girder" and it was explained how the shear method failed in that case, especially if applied to a box girder with flat top and bottom flanges composed of such N-girders.

We can readily see that we must come to the same conclusion if we apply the shear method to an airship as given in Fig. 10, if in that design we depart from the regular polygonal section. Suppose, for instance, that the section in Fig. 10 is modified by the insertion of a flat top and a flat bottom, each consisting of several girders as indicated in Fig. 15. We obtain then an oval section with horizonal major axis, emphasizing the flange strength relative to the web strength. According to the shear method the tension in the wires in the flat parts and the end load on the girders marked A_0 and M_0 in Fig. 15, should be zero, the reason being that if shearing alone is considered, T and F are proportional to the sine of the angle which the panels form with the horizon [see (29″) and (30)]. Actually, if the horizontal panels are provided with shear and counterwires, set up with an initial tension, as they would be in an airship, the longitudinals as well as the wires in those parts will act as flanges of the ship girder. These members cannot escape the elastic bending strains thrown upon them through horizontal shear, any more than the strength deck and bottom plating in the analogous case of an ordinary ship.

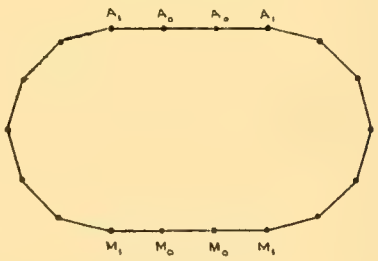


FIG. 15.

If the shear method is applied to an airship of elliptical polygonal section, as shown in Fig. 16,† we should, according to the shear method, get a stress diagram throughout the ship such as shown in that figure, which cannot be correct.

The fundamental explanation of this discrepancy between the stress diagrams obtained by the shear method and those obtained by the bending method in such cases is the follow-

*_Aeronautics_, Feb. 12, 1920.

†Mr. E. H. Lewitt: _Aeronautics_, London, Feb. 12, 1920. The Distribution of Bending Stresses in a "Rigid Airship."

ing. While a stress diagram, as that of Fig. 16, actually obtains in any one frame of such a ship, when a shearing force is applied to the adjacent frame, the excessive forces acting on the longitudinals above and below the neutral axis will, on the length of a few frame spaces, be diverted respectively towards the top and bottom members and bring about a condition more and more conforming to the theory of bending. This is due to the elastic strains in the longitudinals and can be proved to be in accordance with the Principle of Least Work. It conforms to Saint Venant's Principle, according to which the state of stress and strain set up in a bar by a terminal couple is practically independent of the distribution of the forces which constitute the couple, and this is true of all parts of the girder except very near the region of application of the couple. Hence, although the forces which initiate the bending in an airship may not themselves conform to the theory of bending, they will, due to the elastic strains in the structure, tend to adjust themselves to that theory.

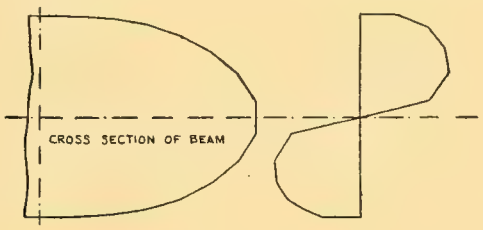


FIG. 16.

As a final argument against the shear method, consider the hypothetical case of a ship subject to a pure bending moment produced by simple couples applied to the ends. In that case there would be no shearing in the structure, and hence the shear method would fail completely to account for the stresses.

Only by a combination of the bending method with a calculation of the local effects of shearing and by superposing the stresses so determined is it possible to obtain a fairly correct and complete solution. Where the system of wiring varies abruptly and where it does not conform to the strength of the longitudinals, a solution may be obtained by reckoning the effective area of the longitudinals to be proportional to the size of the adjacent wires. This question, however, lies outside of the scope of the present paper, which deals particularly with airships of fairly uniform girders and wiring.

IX. SUMMARY AND CONCLUSIONS.

1. A wire, so long as it is in tension, will transmit compressive forces as effectively as an elastic strut.

2. A wire may transmit tension and compression without any sensible change in its tensile stress, as when a free panel is subject to shearing couples which determine a certain tension in the shear wire.

3. When a panel forms part of a larger structure as in an airship, where it is prevented from distorting freely and is subject to shearing combined with tension or compression, the tension in the shear wire is no longer determined by shearing alone as commonly assumed. The tension is then the sum or difference of that due to shearing deflection and that due to the direct pull or compression acting at the joints, but the sum of the vertical components of the tensions in all the wires in one frame space is equal to the total shear force in that frame space.

4. The horizontal forces, whether tensile or compressive, acting at a joint of a panel are directed partly along the longitudinal and partly along the wire (or wires) which meet at the joint, provided the wire is not slack. For each wire may be substituted an equivalent fictitious bar of the same material as the longitudinal and of an area depending on the material of the wire and on the angle which it forms with the longitudinal. If great accuracy is desired, a correction should be applied to this area due to the fact that the tension of the wire corresponds to a location of the fictitious bar midway between the longitudinals which it connects. This is explained in Section VII. The forces directed along the fictitious bar and the longitudinal at each joint are in the same proportion as their areas.

5. The aggregate effect of a longitudinal and adjoining wires, cooperating as explained in (4), is the same as that of a girder of an area equal to the sum of that of the longitudinal and of the fictitious bars equivalent to the wires meeting at the joint. That area is the "effective area" at the joint to be used in calculations of longitudinal strength.

6. Initial tension in the wires prevents or greatly reduces slackness and enables the counterwires to act as effective strength members under many circumstances where they would otherwise be slack. It increases the rigidity of the ship as a whole, reducing in particular the extreme limberness under shearing which is characteristic of wired structures. The final stresses in the structure under shearing forces large enough to slacken the counterwires are the same as if there were no initial tension. Under dynamic actions initial tension lessens the violent strains which are apt to occur when the external forces are reversed and slack wires suddenly tauten up.

7. The bending method can be safely applied with a fair degree of approximation to airships as now usually constructed, and is particularly valuable as a means of comparison between different ships. It should be applied to sections taken through the center of the joints of the frames rather than to sections between the frames.

8. In applying the bending method to an actual airship, it is recommended to deal independently with each frame section as indicated above. Find first by the ordinary bending formula the stresses at the joints in the frame under consideration. Calculate the total forces at those joints due to bending. Find the forces called forth by shearing in the wires and longitudinals of the adjacent frame space which it is desired to consider and superpose on these the components of the forces due to bending. This will give the total forces acting at any given frame and on structural members adjacent to the frame.

9. The method of shears is fundamentally in error when used as the sole means of determining the general stresses in the structure of an airship by a process of summation, because it neglects the elastic strains in the girders.

In conclusion I wish to express my indebtedness to the Bureau of Aeronautics and in particular to Commander J. C. Hunsaker for permission to make use of the various material and data which have been made available to me by that bureau and which have served as a basis for my investigations.

My thanks are due also the aeronautical engineer of the Bureau of Aeronautics, Mr. C. P. Burgess, who introduced me to the subject and who has made several valuable suggestions.

DISCUSSION.

THE PRESIDENT:—You have heard Paper No. 9, "The Longitudinal Strength of Rigid Airships," by Prof. William Hovgaard, a Member of the Society. This is one of those highly valuable scientific papers which it is one of the aims of the Society to encourage and to include in our Transactions.

I do not know whether there is anybody here who is prepared to discuss this paper or not. If there is anyone here who would care to discuss it, we would be glad to have him do so.

COMMANDER EMORY S. LAND, (C. C.), U. S. Navy, *Member:*—I am not quite prepared to discuss this paper on my own behalf exactly, but with a little assistance from the Bureau of Aeronautics of the Navy Department, I have here a discussion which was contributed jointly by C. P. Burgess, Commander J. C. Hunsaker, and myself, which is as follows:

Professor Hovgaard has presented a very clear and interesting exposition of the difficulties involved in the theoretical investigation into the distribution of the loads among the longitudinal and diagonal members of the hull of a rigid airship, resulting from the primary bending and shearing forces. The study of the stresses and deflections in rectangular panels due to combined end and transverse forces is believed to be unique in its exhaustive analysis of this particular problem, and it serves as a most useful introduction to the study of the complex structure of a rigid airship. Care must be taken, however, to bear in mind that the case of rectangular panels, free to deflect, each by itself, under the influence of Professor Hovgaard's P and Q forces, is very different from the actual case of a rigid airship, in which the problem is vastly more complicated owing to the panels being bound together and restrained in their deflections, so that they interact with each other in a way which makes the determination of the P and Q forces for each panel the dominant part of the problem, instead of something given in the hypothesis.

The two rival methods of calculation mentioned by Professor Hovgaard, and designated by the method of bending moments and the method of transverse shears, seem to have occurred independently to several investigators; and, indeed, they follow directly from well-known principles of analysis of complex structures. Both these methods are based on the assumption, known to be only approximately true, that transverse sections plane before bending remain plane after bending, that the longitudinals alone take the primary bending forces, and the shear wires alone take the primary shearing forces.

Professor Hovgaard declares himself in favor of the bending theory, and he has contributed to it the addition of fictitious longitudinal bars to be used as equivalents for the diagonal wires in calculating to what degree these members assist the longitudinal girders in resisting the primary bending moments in the hull. These fictitious bars increase the effective moment of inertia of the cross sections of the hull of a modern rigid airship by about 5 to 6 per cent.

Engineers have been accustomed to regard methods of analysis by moments and by shears as alternatives which should give identical results; but it is found that in the problem of the rigid airship the results are the same only when the longitudinal girders are of equal areas and situated at the apices of regular polygons, and the diagonal wires are of equal size throughout each main frame space, and the shear and counter-shear wires are both effective.

In actual airships there are rather large irregularities in the distribution of the material, especially in the lower part of the hull where the effect of the keel must be considered, and the discrepancy between the results obtained by the two methods may be very great. Engineers may reasonably feel that the existence of such discrepancies casts doubt upon the validity of both methods of analysis, and some amplification of Professor Hovgaard's explanation of the reasons for the discrepancy seems to be called for.

In a steel ship structure, distortion by shear, either transversely or longitudinally, is so small as to be negligible; and in consequence of the very small distortion by longitudinal shear, plane sections remain almost perfectly plane, regardless of the ordinary shearing and bending forces applied to the structure, and the ordinary bending formula is therefore applicable to a high order of accuracy, in spite of structural irregularities. The hull of a rigid airship may appear to be structurally more regular than the average steel ship, but, as Professor Hovgaard points out, it is extremely limber in shear, owing to the shearing forces being transmitted through the hull by very light steel wires. In transverse shear, the deflection of a rigid airship is usually several times as large as the deflection by bending; but it is longitudinal shearing deflections which most interfere with the applicability of the bending theory to the solution of the problem of longitudinal strength.

The bending theory requires that plane sections remain plane; or, in other words, the longitudinal strain of the members must vary in a definite manner. In a rigid airship the stresses, and consequently the strains in the longitudinals, are due to the forces applied by the shear wires at the joints; and it follows that unless the cross-sectional areas of the wires are proportioned in a certain definite manner to the forces to be transmitted, the movements of the joints and the strains in the members will not be such as to maintain plane sections, and the stresses will therefore not be in accordance with the ordinary theory of bending.

Professor Hovgaard uses some examples of irregular structures to show that the method of shears gives erroneous results. He might have carried the examples further and shown the inadequacy of the bending theory to account for the stresses. The truth must always lie somewhere between the results given by the two methods and will, in general, be nearer to the bending than to the shear theory.

Exact solutions of the problem by the Principle of Least Work or by deflections have proved impracticable. Twenty simultaneous equations were required for the solution of the comparatively simple case of four bays of an hexagonal-braced tubular structure having one of the six longitudinal members three times as large as each of the others so as to simulate the effect of the keel of a rigid airship. Probably the ultimate method of calculation will involve the use of correction factors, determined by experience and experiment, for converting the actual areas of the longitudinal members into effective areas. The effective areas will then be used in computing the moment of inertia of the cross-sections of the hull, and in finding the total end load taken by each member.

COMMANDER LAND:—As a result of the various accidents which have happened to rigid airships, and in view of the fact that we are going ahead with the ZR-1, it was deemed desirable and advisable to requisition a committee of outside technical experts to go over the complete work that has been done by the Bureau of Aeronautics on ZR-1 primarily, and also on the work which is being done by the Bureau of Aeronautics generally on lighter than air design.

This committee has done a splendid amount of hard and strenuous work, and I believe

that Professor Hovgaard has done much of the wheel horse work of going into the design and the calculation of these airships; the results of some of these investigations have been presented to the Society this morning. The Navy Department in general and the Bureau of Aeronautics in particular owe this committee a hearty vote of thanks, and I assure you we are very grateful.

I should like to clarify, if possible, one point on page 143. After the sentence reading "The girders are constructed of the lightest metal we possess," I think should be added "due consideration should be given to the strength requirements." The metal referred to is duralumin.

In connection with the matter on page 146, it might be of minor interest to refer to the catastrophe to R-38 (ZR-2). Many of the eye-witnesses insisted that the ship first opened at the bottom, and the statements made with reference to the accident indicated that the strength of the keel girders was the weakest part of the ship. Such is not the case, and the final testimony is to the effect that the ship first opened on the side. The idea of some of the eye-witnesses was probably obtained from seeing one of our own officers fall out through the bottom (Lieut. Commander E. W. Coil, U. S. N.). There was evidently a good deal of misstatement from so-called eye-witnesses. However, Professor Hovgaard's statement relative to keel structure definitely holds so far as R-38 (ZR-2) is concerned.

On the same page, last sentence of the second paragraph, where the author says: "The assumption being that the dynamic forces would be less serious." I take slight exception to that, because I think it was not a question of their assumption being incorrect, as that their knowledge was inconclusive and very incomplete. They felt that if the static forces were taken care of, the dynamic forces would be taken care of by the factor of safety. The known aero-dynamic forces and the data available relative to them were very meager, and unless the Germans have more than we think they have, they still are very meager. The assumption that the aero-dynamic forces will be taken care of by the factor of safety has been proven to be incorrect.

The last paragraph on page 159 puts before you gentlemen the extreme difficulty of attempting to solve the problem before you, where you have shear, tension, compression and torsion forces and do not know where or when you are getting one or more of these stresses acting on a structure as complicated as the rigid airships we have under consideration. I am particularly glad that Professor Hovgaard brought out the analogy to the submarine, because there is altogether too little attention paid in this country to the question of strength of rigids on the part of those interested in the design of submarines; they should get a special benefit from these comparisons made by the professor, and they should help us out. The analogy is very close, the problem is here, and it seems to me that we are up against a stiff problem; there should be more interest displayed in attacking it, in an endeavor to solve it.

The work on this difficult problem has only started, and while Professor Hovgaard has given us a way out, it will require a good deal more work and a good deal more experimental work, both in model design in the laboratory and actual tests of the ships in the air, before we will come to any definite and final results with the aero-dynamic forces. An effort is to be made to go through some actual tests in air with all of the equipment in our airships. Actual air tests were very strongly recommended by the committee which sat on the investigation of the R-38, but lack of funds prevented it being carried out. It will be necessary to check our experimental data with trial data in the air. We have only just begun the attacks on the strength problems.

Lieutenant Commander H. E. Saunders (C. C.), U. S. Navy, *Member:*—I suppose I am one of those to whom Commander Land refers when he says that the submarine fellows should take a day off and read over Professor Hovgaard's paper and learn how to build submarines properly.

I think with propriety, and without revealing any confidences or secrets, I can say that the Bureau of Construction and Repair, especially during the past year, has been making a complete study of the question of strength of submarines. We started away back in the beginning with a clean slate, and we have checked up everything that has developed, everything we knew of, and all the experiments that have been made—and we have been able to get a great deal of information from Germany, both directly and indirectly, and from a study of the vessels taken over after the armistice. In this connection I desire to say that Professor Hovgaard, who has done so much work along this line, has been assisting the bureau in the researches on the strength of submarines, and I would call the attention of the Society to the fact that we are doubly indebted to Professor Hovgaard for the extensive work he is going on with, and the Navy Department hopes, after we have progressed to a certain point with this work, and if we are able to obtain funds with which to carry out experiments, that we will be permitted to give out this information for the benefit of all naval architects who can use it.

The President:—If there is no further discussion, Professor Hovgaard will have an opportunity to make any replies he cares to.

Mr. Henry Goldmark, *Visitor:*—Mr. President, I appreciate very much the opportunity of saying a word or two on this subject. During the last summer a committee of five engineers, of which I have the honor of being the chairman, has been engaged upon the question of the structural strength of rigid dirigible airships, with special reference to the airship ZR-1 now being built by the U. S. Navy. I would like to emphasize the fact that Professor Hovgaard, a member of the committee, gave us most novel and valuable information from the studies he has made on this subject. The structural frame of a dirigible airship is very different from any other form of structure. The requirement of great lightness, as well as strength, has made it necessary to use a new material. The metal used, duralumin, an alloy of aluminum, with 4 per cent of copper and small percentages of magnesium and manganese, is a very wonderful mixture. It has a tensile strength of fully 55,000 pounds per square inch—i. e., as much as soft steel—with an elongation of 18 per cent in 2 inches. The compression members which are used are extremely light and, at the same time, have a compressive strength comparable, at least, with what we get from steel.

There is no doubt that in this field, as in all other similar fields, the test of actual service is the ultimate criterion. These airships have been constructed since the beginning of the century, but most of them have been built in the last ten years. The experience with them has been very largely in Germany, to some extent in England, and the ships under the very severe conditions of war service have stood up remarkably well.

The consequence is that it has been possible to arrive at something in the way of standardization and at factors of safety which can be safely used in structures of that kind. They are somewhat lower than in structural steels, such as are used in bridges and buildings and ship work, but not so very much lower, if we consider the fact that the compression members in ordinary structural work are usually strained to about half the actual compressive strength as shown on full size tests. In airships the factors of safety are lower than 2,

but not so very much lower; at any rate the test of experience has shown that they are sufficient.

As stated in Professor Hovgaard's paper, the forces to be sustained by the airship are three-fold—the weight of the ship, the buoyancy, and gas pressure—all of which would be quite definitely known in any given case, and the aero-dynamic forces due to atmospheric pressure, when the ship is being propelled in service. These last forces are gradually becoming known by experiment, and fuller knowledge of them will be available in the near future.

As to the theory of the longitudinal strength of which Professor Hovgaard treats in this paper, it is quite clear that the ship, as a whole, bends like a truss or beam, but unfortunately the number of parts is so great that it is impossible to apply the method of least work or other method, based on the theory of elasticity to determine the stresses.

The best we can do is to use approximate methods and check them up by careful reasoning, with the expectation of some day getting a sufficient number of strain measurements on airships in service to arrive at more correct results.

Professor Hovgaard has added very much to our knowledge of the theory of the stresses on which there has been a lot of loose reasoning in the past. His studies have helped our committee to get a much closer idea of what the stresses are in this complex structure, and the present paper constitutes a decided advance on what has previously been published on the subject.

Mr. Elmer A. Sperry, *Member* (Communicated) :—I wish to add my word of appreciation of the splendid work that Professor Hovgaard has done in the researches and calculations connected with the preparation of his paper.

When contemplating the labyrinth of detail wherein maximum strength and minimum weights have to be kept constantly before the designer as the goal of his achievement, it is of course perfectly apparent to the experienced engineer that neither of these can be completely attained. As in the case of most other engineering, it must necessarily be a matter of compromise.

From these considerations my mind runs out to the performance of the finished structure and especially the limitations in the prescription for its tests. In fact, no one can think in terms of either rigid or semi-rigid airships without having prominently rise before him the nightmare of the disastrous failure of the R-38. Nothing is more apparent than the fact that demands can very easily be made on these airships that they cannot be expected to withstand, and, as one who for many years has been required to consider just how far to go in tests of new constructions and new developments, I wish to put out a word of warning. It should be approached with great caution and, in addition to very complete knowledge of the minutest detail as well as the structure as a whole, a certain amount of sympathy for structures based on ripe experience, in the same sense that one can have quite complete sympathy with a machine and intuitively sense its limitations so as not to make demands upon it, especially at first, that it cannot be expected to easily fulfill, letting subsequent experience guide as to where the increased severity of the tests should stop.

In preparing tests, I have an innate feeling that someone seasoned and experienced should be consulted or depended upon to make the final decision, who would prescribe treatment that is calculated to fit the ensemble, including its appendages, and also its environment as a whole, all those unseen and more subtle forces acting both from without and within. Why should not our author, who has made such an extensive study of all the features, be among those to be considered? It is perfectly apparent that the untrained enthusiast often imagines, inasmuch

as performance has reached a certain point, that it can be considerably extended or extended indefinitely. We know that this is not true, and I am hoping that some master mind of experience and caution may be depended upon to guide in the tests of the great dirigible nearing completion, that will safeguard it against early destruction or dying in infancy by increasing the severity of the tests to a point beyond anything that should ever be demanded. In this instance let us hope that ripe and mature judgment will take the place of enthusiasm and brainstorms in the matter of excessive demands or performance of our great product, so that she will live long enough to fulfill her mission in securing at least a part of the great mass of data that we need to make definite progress in an art that has such transcendent promise as does the one before us. It is certainly *prima facie* that these delicate structures must receive treatment according to the "nature of the beast" to a degree probably not required in any other branch of the entire engineering art.

PROFESSOR HOVGAARD:—I am much indebted to the members who took part in this discussion, especially Commander Land, speaking for himself, Commander Hunsaker and Mr. Burgess, all of the Bureau of Aeronautics. Commander Land states that the true solution lies between the method of shear and the method of bending. This is, of course, true in a certain sense and is pointed out in the paper in my conclusion No. 9, where I say that the shear method should be used locally in cases where the wiring does not harmonize with the distribution of the longitudinals; I ought perhaps to explain this more fully.

By the bending method, we can determine the horizontal shear exerted by the wires in any panel. This should check with the horizontal component of the tension of the wires as determined by the vertical shear in the frame space, but where the wires are not properly proportioned to the longitudinals a discrepancy will occur. If the discrepancy is serious, it must be taken into account in applying the bending method. This happens in L-49 in the *KM* panels, adjacent to the heavy keel structure, where the wires are too light to secure a complete cooperation of the heavy keel with the rest of the ship in bending. A discrepancy, although less serious, is found also in the panels between the *A*, *C*, and *E* girders.

In illustration, consider the case of a beam lying in the hold on the bottom of a ship, which is exposed to sagging strains. If the beam is entirely free, it contributes, of course, nothing to the longitudinal strength of the ship, but if it be lashed down with transverse lashings to the bottom, so as to be forced to follow the vertical deflections of the ship, it will offer resistance as an individual girder quite independent of the ship girder. To the strength (moment of inertia) of the ship must, therefore, be added simply the strength (moment of inertia) of the beam itself. Now, imagine the beam to be further connected to the ship by horizontal or oblique lashings. It will then come to oppose the elongation of the bottom and will cooperate as an integral part of the ship in resisting the bending to an extent determined by the strength of the horizontal lashings.

In an airship like L-49, analogous conditions exist, inasmuch as the keel, consisting of no less than six longitudinals, forms a heavy triangular girder, which by the transverse frames is forced to follow the vertical deflections of the rest of the ship, but which is in shearing connection with it, only through the relatively light *KM* wires. If we calculate the horizontal shear forces in the *KM* panels required by the bending method, we shall find that it is much greater than that actually obtained by the vertical shearing deflection in any given frame space. It follows that the keel cannot cooperate in a complete manner with the rest of the ship.

This difficulty I propose to overcome without departing from the bending method, by conceiving the keel and the remainder of the ship as separate and independent girders, except in so far as they have the *M* girders in common. Imagine the *M* girder to be divided into two parts, proportioned to the horizontal shear forces in the *KM* and *MN* panels, and allotted respectively to the ship and to the keel, we may then regard the keel and the rest of the ship as entirely independent of each other and calculate the stresses in each according to the bending method. A similar procedure may be followed in the longitudinals *A* to *E*.

I do not claim that this solution is mathematically exact; it is, of course, an approximation. Actually, I propose to take into account not only the bending but also the shearing deflection of the keel, and I make allowance for any possible difference in stresses in the two parts of the *M*-girders as determined by this method. Without taking up too much of your time, I cannot go deeper into this question at present, but I hope to have proved that it is necessary to follow primarily the bending method and to use the shear method in a subsidiary capacity. I object to the latter method only when used as the *sole* means of calculating the stresses, especially because the elastic strains in the longitudinals and the horizontal shear forces thereby created are neglected.

Applying the method of calculation here recommended to a modern rigid airship, it is found that the moment of inertia of the ship girder, considered apart from the keel, is increased by about 8 per cent due to the main and secondary wires, substituting for them the equivalent or fictitious bars. If, moreover, the wire netting is included with due allowance for its curvature and tension due to the pressure of the gas cells, the moment of inertia will be increased altogether by about 10 per cent. This is nearly twice the amount of that determined by the ordinary mode of calculation as given by Commander Land.

I wish to thank Mr. Sperry for his very appreciative remarks, and I quite agree with him that great caution should be exerted in carrying out the tests with the ZR-1, but I believe that the Bureau of Aeronautics is fully aware of this and that all possible precautions will be taken. In fact the program of the tests, which is very detailed and complete, is so planned as to pass systematically and with caution from the simplest and easiest tests to the more severe tests by gradual stages under most careful observations of the behaviour of the ship and of all its parts. Such limitations are imposed for the first tests on speed, and on the use of the machinery, rudders, etc., as to make serious accidents extremely unlikely. Minor failures may of course occur, but it is believed that such weaknesses, should they appear, will be readily corrected without further trouble.

THE PRESIDENT:—Professor Hovgaard, on behalf of the Society, I wish to extend our thanks to you for this very valuable paper.

AMENDMENTS TO THE CONSTITUTION AND BY-LAWS.

THE PRESIDENT:—There is an important matter we want to take up, consider and discuss, if necessary, and reach a conclusion. I have been asked to make a brief statement about it, because, unfortunately, Mr. Stevenson Taylor, who is chairman of the committee which had it in charge, is not here for the moment, and, I believe, is not likely to be present at this session.

It has been the custom, heretofore, in selecting members of the Council to have a Nominating Committee appointed to prepare the ticket. The committee this year, after carrying out its duties, made a report to the Council, in which attention was called to some objections to the methods which have been followed for a number of years, in accordance with the Constitution. Many of us were quite familiar with these objectionable features, particularly those who, like myself, had served at times on a Nominating Committee. I will recall to you just what they are, so that you will understand the subject thoroughly.

The outgoing Members and Associate Members of the Council are automatically renominated, their names going on the ballot without any action. In addition, three members are put on the ballot, and one additional associate. This ballot goes out to the membership, and six members out of nine are elected as members, and two associates out of three on the list are elected as associates.

There are some objections to that system, as you can readily see. In an organization like our own, where there are no cliques and no factions, it seems a pity to put up the names of good men, simply to have them knocked down. That came about, however, for reasons which it is not necessary to go into at present. The committee called attention to the fact that, under this system of renomination, it might happen that there would be cases of nominees who had not been zealous in attendance on council meetings, and who had shown no particular interest in the Society; nevertheless, their names would go on the ballot just the same. Unfortunately, as my experience on the Nominating Committee several times has shown, the membership at large is not well enough acquainted with everybody in the Society to be able to discriminate, nor would it have any means of knowing who are the members of the Council who attend to their duties and show real interest in the affairs of the Society, and who do not.

The result has been that several amendments were drawn up and submitted to the Council in accordance with the Constitution, having been prepared by ten or more members. These amendments came up before the Council meeting yesterday morning, and after being read over and discussed, were referred to a special committee for careful consideration and report this morning. That report was made, which substantially approves all of the things recommended—there were slight changes in phraseology, but the amendments were recommended by the committee for adoption substantially as proposed.

Then each of these items was taken up seriatim, and again read; opportunity was given for discussion, and they were finally voted on by the Council. As a result we now have ready to present, to the membership of the Society at large, these proposed amendments, properly prepared in accordance with the Constitution, having been carefully considered by the Council, and coming before the Society with the unanimous recommendation of the Council that they be adopted.

I will now ask Captain Chas. A. McAllister, on behalf of Mr. Stevenson Taylor, chairman of the committee, to read these proposed amendments. I may say before he does, that the amendments relate to only a few of the articles in the Constitution; the real changes relate entirely to the method of electing the Council. The other changes which he will read are merely changes in phraseology. I may explain also that we have omitted a number of sections, which you will see encumber the Constitution with explanatory matter, which is no longer necessary; for example, in our early days, we elected two vice-presidents each year for a term of six years; this was changed to four each year for a term of three years.

CAPTAIN CHAS. A. MCALLISTER:—I regret we have not a sufficient number of copies of these proposed amendments to hand a copy to each member present. They were not finally in form to submit until ten o'clock this morning, and we have only two copies.

The proposed amendments to the Constitution and By-Laws were then presented, and the remarks indicated below were interjected at the places indicated.

Captain McAllister read the amendments as follows:

ARTICLE I—*Section 2,* to be amended to read as follows:

"Its object shall be the promotion of the art and science of shipbuilding, commercial and naval, *in the United States of America.*"

ARTICLE IV to be divided into two Articles, IV and V.

ARTICLE IV—*Officers,* to be amended to be—"ARTICLE IV—*Council,*" to read as follows:

"1. There shall be a Council composed of eighteen Members and nine Associates, and the President, Past Presidents, Honorary Vice-Presidents and Vice-Presidents shall also be *ex-officio* Council members."

THE PRESIDENT:—The reason for the increase in the number of Associates is that the merchant marine is becoming more important all the time, and we wish to stir up the interest of that branch and secure greater cooperation.

"2. The Council shall meet at the call of the President just prior to the annual general meeting of the Society and at such other times as the interests of the Society may demand.

"3. At all meetings of the Council, eight Members thereof shall constitute a quorum.

"4. The term of office of Council Members shall be three years.

"5. (*a*) Prior to September 1 of each year, the Executive Committee shall prepare ballots for filling the places of the retiring Council Members. The ballots shall contain the names of six Members and three Associates of the Society, and shall be mailed as soon as practicable after September 1 of each year to all Members and Associates."

THE PRESIDENT:—It is provided that the Executive Committee shall nominate the exact number that are to be elected, instead of putting up the names of good men simply to be knocked down. The Executive Committee, after careful consideration, is to prepare a ballot covering the necessary number.

You will see that the only objection that could possibly be made would take some such form as this: "Suppose the Executive Committee should nominate people not acceptable to

the membership at large; suppose it is desired to make a change in one or two names, or suppose the membership at large does not like any names on the list."

The next section provides an adequate method to take care of such a contingency, so if the membership is not satisfied with the nomination made by the Executive Committee, then an independent ticket can be sent to the secretary, who must send it to the entire membership, which can vote for either ticket as it pleases.

ARTICLE IV—*Section 5 (b)*, to read:

"An independent nomination for Council Members may be made in writing by not less than thirty Members and Associates, of which number at least two-thirds must be Members, and if such nomination is received by the Secretary prior to September 15, ballots shall then be prepared by him, containing the names of those thus nominated, and these ballots shall also be mailed to the membership.

"(*c*) Each member may vote for not more than six Members and three Associates, and each Associate may vote for not more than three Associates to be Council Members.

"The ballots shall be returned to the Secretary and canvassed by the Council at its meeting just prior to the annual general meeting of the Society; and the six Members of the Society and the three Associates receiving the highest number of votes shall be declared elected Council Members.

"(*d*) A vacancy in the office of Council Member shall be filled by the Council for the unexpired term.

ARTICLE V—*Management,* to be amended to be—"ARTICLE V—*Officers,*" and to read as follows:

"1. The Officers of the Society shall consist of a President, Past Presidents, Honorary Vice-Presidents, twelve Vice-Presidents and a Secretary and Treasurer."

THE PRESIDENT:—The wording as to the election of the President is identical with the present Constitution and is put in this proposed amendment to make the paragraph complete. The old Constitution put the officers and Members of the Council under one article, while the proposed amendment makes two articles.

"2. *Only* Members and Associates of the Society are eligible for the office of President, Honorary Vice-President or Vice-President."

THE PRESIDENT:—In the paragraph about Honorary Vice-Presidents, to be read in a moment, there is a change. At present the Honorary Vice-Presidents are chosen only from the Vice-Presidents. Under the proposed amendment, Members of the Council who have served twelve years, as well as Vice-Presidents who have served twelve years, will be eligible for election as Honorary Vice-President.

"3. (*a*) At its meeting just prior to the annual general meeting of the Society held in the year with which the term of the President expires, the Council shall nominate a candidate for the office of President whose name shall be presented to the Society at the said annual meeting.

"(*b*) The nomination of any other candidate signed by at least sixty Members and Associates, of which number at least two-thirds must be Members and submitted to the Secretary prior to the annual meeting, shall also be presented.

"(*c*) The candidate receiving the highest number of votes shall be President for the ensuing three years.

"(*d*) A vacancy in the office of President shall be filled by ballot by the Council from the list of Past Presidents, Honorary Vice-Presidents, and Vice-Presidents, until the end of the year in which the vacancy occurs, and at the annual general meeting of that year a new President shall be elected for three years in the manner prescribed in the preceding paragraphs.

"(*e*) The President shall not be eligible for election as his own successor."

ARTICLE V—*Section 4*, to read:

"Honorary Vice-Presidents may be chosen from the list of Vice-Presidents or from the list of Council Members who have had at least twelve years' service. They shall be chosen at the meeting of the Council next prior to the annual general meeting of the Society, and shall be the unanimous choice of all Council Members present.

"Not more than two Honorary Vice-Presidents may be elected in any one year.

"5. The Vice-Presidents to fill the vacancies occurring each year shall be elected by the Council from its own membership. Retiring Vice-Presidents shall be eligible for re-election. The term of office of the Vice-Presidents shall be three years.

"6. The Secretary and Treasurer must be a member of the Society and shall be elected annually by the Council, but may be removed for cause at any time by a majority vote of Council after due notice has been given."

THE PRESIDENT:—That last paragraph, gentlemen, is simply a change of phraseology. It agrees exactly with the present practice and what has been the practice from the beginning of the Society. When the Constitution was first drafted, it was apparently thought there might be an arrangement, for example, to have a trust company or bank act as treasurer, and it then stipulated that the Secretary must be a Member. The practice of the Society, however, in the whole twenty-nine years of its existence, has been to have the same person as Secretary and Treasurer to do its work, so we thought it better, when we were revising the Constitution, to make the phraseology agree with our practice.

ARTICLE V—*Management* to be made "ARTICLE VI—*Management.*"

ARTICLE VI—*Meetings* to be made "ARTICLE VII—*Meetings.*"

ARTICLE VII—*Regulations and By-Laws* to be made "ARTICLE VIII—*Regulations and By-Laws.*"

ARTICLE VIII—*Amendments* to be made "ARTICLE IX—*Amendments.*"

THE PRESIDENT:—Has anyone any comment to make on the proposed amendments? I want again to call your attention to the fact that the matter has been under consideration for a long time. I should say it is some six weeks since the matter was started, and it has been given very careful consideration. Mr. Stevenson Taylor, who is now really the dean of the profession and a man whom we all love and admire, is the one who started the movement. This Society is very near and dear to his heart. I do not know of any member who has done more to advance the interests of the Society than Mr. Taylor, or one who would hesitate more seriously to take a step which in any sense might imperil those interests. Ten or more Members gave their approval to the amendments, and then they came up for consideration before the Council. There they received the scrutiny of such devoted friends and experienced members of the Society as Commodore Baxter, Secretary of the Society for many years; Admiral Capps, Secretary of the Society at one time, and afterwards Presi-

dent, and who, like Mr. Taylor, has devoted himself to our interests for a great many years; and Mr. Daniel H. Cox, who has been Secretary for the past ten years, and who knows about these matters very thoroughly. On the Council there are also a great many of us who are deeply interested in the welfare of the Society. These proposed amendments to the Constitution and By-Laws have passed the scrutiny of all these men, with ample time and opportunity for discussion, and they are now presented to you for action.

Mr. Mason S. Chace:—I think these changes will be an advantage, and I see no disadvantage to them, and I move their adoption.

The motion was seconded by Mr. P. J. McAuliffe and Mr. John L. Bogert.

The President:—All in favor of the adoption of the proposed amendments to the Constitution and By-Laws say "Aye"; contrary-minded, "No." The vote appears to be in favor. It is so declared and the amendments are adopted.

The meeting then adjourned until 2.45 o'clock.

FOURTH SESSION.

THURSDAY AFTERNOON, NOVEMBER 9, 1922.

President McFarland called the meeting to order at three o'clock.

THE PRESIDENT:—Before we go on with the papers assigned for this afternoon, I am going to take the pleasure of presenting to you a gentleman whom many of you know, perhaps, personally, and nearly all of you by reputation. He is the man who has done more in recent months to stir up interest in and publicity about the American merchant marine than any other one man I know. He is really the father of this Joint Cooperative Exhibition that is going on at the American Marine Show and is the head of a great publishing house. He is familiar with questions of publicity and knows how to present them, and he has done wonderful work in securing proper publicity in connection with the campaign for an American merchant marine. That subject, during the last two years, since he has been active in this matter, has achieved a great deal more publicity than it ever has received before. He would like to say a few words to you about the exhibition here of the American Marine Association, and we shall be glad to hear anything else which he cares to say on the subject of the American merchant marine. I have now the pleasure of introducing to you Col. E. A. Simmons, president of the Boardman-Simmons Publishing Company.

COLONEL SIMMONS:—Mr. President and gentlemen, I have not much to say except this —that the American Marine Association is very glad indeed to have you here with us. At this moment we do not know about our plans as to 1923; the immediate future will decide that. But I do want to say this—that if we hold another exhibition next year, we here and now extend an invitation to you gentlemen to join with us just as you are doing this year.

It has been an experiment in a way, this getting together of the several interests in the marine field; and in so far as I have observed, it has been quite successful. It is the first time in the history of the American merchant marine that they have ever been able to get together under one roof—every participating organization in that field. And again I say we are very glad to have had you with us; and we will be glad to welcome you again in 1923. I thank you. (Applause.)

THE PRESIDENT:—At the meeting of the Council held immediately after the close of the morning session, a number of applications for membership in the Society were received and acted upon by the Council. The Secretary will read the list of these applications for membership which have been acted on favorably by the Council, and are recommended to the Society for approval.

THE SECRETARY:—The following names have been recommended for election to the various grades:

Members (18).

Henry G. Avery, Chief Draughtsman, W. and A. Fletcher Company, Hoboken, N. J.

Edward A. Colson, Chief Operating Engineer, Marine Department, Babcock & Wilcox Company, 85 Liberty Street, New York, N. Y. P. O. address: 241 Charles St., Westfield, N. J.

Peter J. Dromgool, Superintendent Engineer, Pan American Petroleum & Transport Company. P. O. address: 824 Whitney Bank Building, New Orleans, La.

Oscar D. Duncan, Attorney, Duncan & Mount. P. O. address: 27 Williams Street, New York, N. Y.

Thos. Durkin, Fleet Engineer, Cleveland-Cliffs Iron Company. P. O. address: 1318 West Boulevard, Cleveland, Ohio.

Whitney J. Eisler, Surveyor, American Bureau of Shipping, Shanghai, China.

Sidney L. Eason, Operating Assistant, Wilmington Steamboat Company (Wilson Line), Wilmington, Del.

Louis R. Ford, Engineer, Morse Dry Dock and Repair Company, Brooklyn, N. Y. P. O. address: 1223 Avenue L, Brooklyn, N. Y.

James Graham, Marine Superintendent of Erection, The Babcock & Wilcox Company, New York, N. Y. P. O. address: 22 Lake Avenue, Mariner's Harbor, S. I.

Norman Hubbard, Chief Draughtsman, Marine Department, Babcock & Wilcox Company, New York, N. Y. P. O. address: 10 De Hart Place, Elizabeth, N. J.

William P. Lambert, Marine Superintendent, The Carolina Company, Charleston, S. C. P. O. Address: 57 Cypress Street, Charleston, S. C.

A. Ross Mackay, Engineer, Marine Department, Babcock & Wilcox Co., 85 Liberty Street, New York, N. Y.

Eugene McCarthy, Marine Surveyor, American Bureau of Shipping, San Francisco, Cal. P. O. address: 1012 Capuchino Avenue, Burlingame, Cal.

Peter McIntosh, Marine Superintendent, W. R. Grace & Co. P. O. address: 2 Malden Avenue, Jamaica, L. I., N. Y.

Dennis W. Murphy, Surveyor, American Bureau of Shipping, Shanghai, China.

Arthur C. Rohn, Acting Manager of Sales, Federal Shipbuilding Corporation, Kearney, N. J. P. O. address: 184 Springdale Avenue, East Orange, N. J.

William H. Stone, Production Superintendent, Cristobal Shops, Mechanical Division, The Panama Canal. P. O. address: Box 1377, Cristobal, Canal Zone.

Walter B. Tardy, Assistant to President, Schutte & Koerting Company, 12th and Thompson Streets, Philadelphia, Pa.

Associates (7).

Clarence Samuel King, Secretary, Atlantic Coast Shipbuilders' Association, 1701 Walnut Street, Philadelphia, Pa.

John A. Kissick, Treasurer, Merchant Shipbuilding Corporation, 39 Broadway, New York, N. Y.

Emmet J. McCormack, Treasurer, Moore & McCormack Company, 5 Broadway, New York, N. Y.

Akira Natsuka, Assistant Manager, Steamship Department, Suzuki & Company, 220 Broadway, New York, N. Y.

Tomokata Soga, Manager and Superintendent, Kokusai Kisen Kaisha. P. O. address: 372 Park Avenue, East Orange, N. J.

William H. Stayton, Sr., President, Baltimore Steamship Company, Baltimore, Md. P. O. address: University Club, Baltimore, Md.

Shigeru Uchida, Manager, New York Office, Osaka Shosen Kaisha, 904 Woolworth Building, New York, N. Y.

Junior (1).

Leo J. Levit, United Electric Light & Power Company, Hell Gate Station, 134th Street and Locust Avenue, New York, N. Y.

THE PRESIDENT:—You have heard these names, gentlemen; a motion to adopt the recommendation of the Council and admit them to the various grades will be received.

PROFESSOR H. C. SADLER:—I so move.

The motion was put to vote and carried.

THE PRESIDENT:—The first paper for the afternoon session is one that ought to be of a great deal of interest to all of us, and it is entitled "Machinery and Trials of the Passenger Ships—American Legion Class," by Mr. Robert Warriner, Chief Engineer of the Bethlehem Shipbuilding Corporation, and a Member of the Society.

Mr. Warriner, in the presentation of the paper, stated:

"When Mr. Rigg read his paper on the design and construction of passenger ships at the Society meeting last year, it was suggested that there should be a paper on the machinery for the ships in the class of the American Legion, and this paper is therefore presented to the members of the Society, and it is hoped will prove interesting, as there are included in our paper the results of a test of the tank on a model with rudder, a self-propelled model, and also we give standardization trials of one of the ships at the exact draught at which the model was drawn.

"Mr. Rigg has already given us a considerable amount of information regarding these ships, and in the paper you will find brief particulars which are necessary to have in mind to consider the results of the model tests and standardization trials. The vessels are of the shelter-deck type, with straight stern, and through the stern the frame is constructed in a longitudinal section."

Mr. Warriner then abstracted the paper at some length.

MACHINERY AND TRIALS OF THE PASSENGER SHIPS—AMERICAN LEGION CLASS.

By Robert Warriner, Esq., Member.

[Read at the thirtieth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 8 and 9, 1922.]

When Mr. Rigg read his paper on "The Design and Construction of Passenger Ships" at the last meeting in November, it was suggested that there should be a paper on "The Machinery of the Passenger Ships, American Legion Class," and this paper is, therefore, offered for the consideration of the members of the Society in the hope that it will be found interesting from the added circumstance that for these ships we have the results of a model with rudder pulled in the tank at Washington, D. C., a self-propelled model run in the same tank, and a fairly good standardization trial of the completed ship at a draught corresponding to one of those at which the models were tested.

Mr. Rigg has already given a considerable amount of information in regard to these ships in his paper (Transactions of the Society of Naval Architects and Marine Engineers, 1921), so that it is only necessary in this paper to give those particulars which have a direct bearing on the propulsion of the ships.

These vessels are of the shelter-deck type, with straight stem and cruiser stern. The framing is constructed on the longitudinal system, except at the bossing and at the ends. The shell plating is arranged with in and out strakes, with overlap butts below the water line. The principal dimensions are as follows:

Length overall	535′ 0″
Length between perpendiculars	518′ 0″
Breadth moulded	72′ 0″
Depth to shade deck	50′ 0″
Designed load draught from base line	30′ 0″
Corresponding displacement (tons)	20,980
Trial draught	24′ 0″
Trial displacement (tons)	16,013
B. coefficient on 24′ 0″ draught	0.604
Coefficient of M. S. on 24′ 0″ draught	0.985
Prismatic coefficient	0.615
Wetted surface (sq. ft.)	45,800

The two propeller shafts are supported by cast steel spectacle frames in two pieces, bolted together at the center line of the vessel, and the framing and plating of the ship are bossed out from where the stern tube intersects the hull proper to the point where it attaches to the spectacle frame. The keel is of the flat type and the rudder balanced, with double steel plates over cast steel frame.

The propellers are located with their centers 10 feet 9 inches forward of the rudder axis.

Bilge keels are fitted at the turn of the bilge and extend along the ship for a distance of 190 feet. They are 15 inches deep with double angles at the shell and stiffened at outer edge with a half oval.

The vessels of this size and type were constructed in three different shipyards, two by the Newport News Shipbuilding and Dry Dock Co., nine by the New York Shipbuilding Corporation, and five by the Bethlehem Shipbuilding Corporation, Ltd., at the Sparrow's Point Plant. The machinery, therefore, while having the same general features, varies considerably in detail. The Hawkeye State, now the President Pierce, built at Sparrow's Point, is the vessel which was run through the standardization trials, and it is the machinery of this ship which is briefly described in the paper.

The engines are designed for 12,000 shaft horse-power on two shafts, and each shaft is driven by compound turbines through single-reduction gear. The turbines are of the Curtis type, and each high-pressure unit consists of twelve impulse stages. The first stage has a single wheel with two rows of 1-inch blading on a 36-inch diameter pitch circle. The remaining eleven stages each consist of one wheel with a single row of ¾-inch blading. The pitch circle diameter of these wheels varies from 34¼ inches in the second stage to 36¼ inches in the twelfth stage. The diaphragms between the wheels are of cast iron with nickel steel nozzle plates cast in and extend from the casing down to the hub of the wheels, where they are sealed by serrated brass packing.

The low-pressure turbines have seven stages, each stage consisting of a single wheel with a single row of 1-inch blading, and the pitch circle diameters vary from 49½ inches in the first stage to 54 inches in the seventh stage. The diaphragms are of similar construction to high pressure.

The astern turbine is located at one end of the low-pressure turbine and consists of two stages, each stage having a single wheel with two rows of 1-inch blading, and the pitch circle diameter is 36⅜ inches for the first stage and 39¼ inches for the second stage.

These turbines were built by the Fore River Plant of the Bethlehem Shipbuilding Corporation, Ltd.

The first stage nozzles of both ahead and astern turbines are machined and carefully reamed to gauge. The first stage ahead has eight open nozzles—that is, only controlled by the main throttle valve—and two sets of three nozzles, each set controlled by an individual valve so that the power can be varied from 7,000 to 13,000 shaft horse-power in three stages so as to get the greatest advantage of full boiler pressure. One peculiar feature of these turbines is that the blading is all of the same hand, the right and left-hand rotation being obtained by turning one set of turbines end for end. When going ahead the steam flows aft through the port turbines and forward through the starboard turbines.

The reduction gears, built by the Falk Company, are of simple construction and of ample proportions. They are single-reduction gears with two pinions and main gear wheel in a single plane. The pinions are 9.143 inches in diameter at the pitch circle with 32 teeth, and the wheels are 131.143 inches in diameter at the pitch circle with 459 teeth. The width of the working face is 36 inches. The pinions are made of chrome vanadium steel, heat treated, and the main gear wheel is of cast steel in one piece with the teeth cut in the rim. These gears have given excellent service so far and show every indication of having a long life. The main thrust, which is of the Kingsbury type, is incorporated in the forward end of the gear casing and is 25 inches in diameter.

The line shafts are solid mild steel, 15¾ inches in diameter with solid couplings and are raised to 16 inches diameter for the bearings. The propeller shafts and stern tube shafts

are 17¾ inches diameter with composition sleeves about ⅞ inch thick shrunk on in way of bearings, the latter being of lignum vitae. The line shafts are 169 feet 5 inches long from the coupling of the gear shaft to the center of the propeller, and each line has seven bearings 24 inches long. The bearings are lined with white metal and arranged for ring oiling.

The screw propellers are made of bronze, and are solid, three-bladed, 16 feet 6 inches diameter, 17 feet pitch, and each has 80.7 square feet of developed surface and 69.4 square feet of projected surface. They are machined to pitch on the driving faces, balanced and polished. Plate 54 shows the form and gives full particulars of these wheels.

The lubricating oil is arranged on the gravity system with two pumps, two coolers and one gravity tank to each engine.

There is one V-shaped condenser to each engine with built steel shell, rolled brass tube plates and cast iron water ends. There are 4,405 ⅝-inch diameter tubes, 10 feet long between tube plates, making the cooling surface 7,200 square feet.

A section of the bottom tubes is pocketed to form a cooling chamber over which the air and vapor must pass on their way to the air ejector suction.

The turbines, condensers, condensate pumps, air ejectors and lubricating system make a complete unit for each shaft.

The boiler installation consists of eight water-tube boilers of the Yarrow type, arranged in two boiler rooms. The total heating surface in the eight boilers is 40,000 square feet. The tubes are 1 inch outside diameter, 0.095 inch thick, except for the two rows next to the fire which are 1¼ inches outside diameter, 0.109 inch thick. Superheaters of the Foster type are fitted, enclosed in the tube nest so that they can be drawn into the stokehole by removing the covering plate. The total superheating surface is 5,000 square feet, and they are located so that the temperature of the gases will be from 900 to 1,000° F.

The boilers have cylindrical steam drums, 4 feet 2 inches diameter, and 12 feet 9 11/16 inches long, which are large enough to furnish ample steam space and a reasonable amount of reserve water. The water drums are also cylindrical and are 2 feet 6 inches in diameter.

The boilers are oil fired, using mechanical burners and closed stokeholes. The burners were originally of the navy type, but the stokeholes did not prove very comfortable and on the last two ships they were changed to Dahl burners, which resulted in the ships being able to make full power on natural draft and allowed of working under much more favorable conditions. The remaining three ships of this group will be changed accordingly.

[The boilers installed on the passenger ships of this class, built at the New York Shipbuilding Co., are as follows:

Number of boiler rooms	2
Number of boilers	8
Type	Water tube
Make	Babcock & Wilcox
Working pressure (pounds)	265
Superheat	75°F.
Total heating surface (4 boilers) evaporating surface	41,376
Total superheating surface (4 boilers)	4,160
Draft	Forced, closed stokehole (1″)
Fuel	Oil
Number of burners per boiler	7
Type of burner	B. & W.

The boilers are of the Babcock & Wilcox regular marine type having 42-inch diameter steam drum and 2-inch O. D. tubes. The superheaters are of the Babcock & Wilcox type mounted on top of the boiler back of the steam drum. The superheater consists of two horizontal headers, mounted horizontally one above the other at the outboard side of each boiler. A double row of U-shaped tubes extending across the boiler has its ends expanded into the two horizontal headers. The boiler is so baffled that the gases of combustion pass vertically up through the boiler tubes at the rear end of the boiler, then over the superheater tubes, then down a second pass through the boiler tubes, and turning again go up a third pass to the uptake and stack.]

It is not intended to give a full description of all the parts of this machinery, and it would be very wearisome to discuss all the various auxiliaries which make up the equipment. They are, therefore, presented in the table on pages 191 and 192.

The arrangement of machinery in outline, together with the lead of the shafts and position of the propellers, is shown on Plate 55.

The distance from propeller tips to hull plating at the nearest point is 2 feet 5½ inches.

The model for the vessels of this class was towed in the tank at Washington, D. C., under various conditions, and Plate 56 shows a copy of the curves of the effective horsepower and speed developed from these tests. The curves given are for hull with rudder.

Some time later it was decided to make further tests on self-propelled model and the results of these are also given on Plate 3. On this test, the propeller represented those which were fitted on the American Legion. These are built propellers, three-bladed, with cast-iron bosses and bronze blades, 17 feet diameter, 18 feet 6 inches pitch, with a developed area of 84.4 square feet, and projected area of 71.499 square feet, and were intended for about 110 revolutions at full power.

The curves estimated from the tests show the shaft horse-power, revolutions per minute, and propulsive efficiency at 24 feet, 30 feet, and 36 feet draught. There have been added, for comparison, the estimated shaft horse-power, revolutions per minute, and propulsive efficiency, at 24 feet draught for the propeller of the President Pierce. These are shown in dotted lines.

It has been noted that the propellers on the President Pierce vary from those used on the self-propelled model, the revolutions having been increased from 110 to 125 in order to obtain a more reasonable reduction gear. At the same time, the substitution of a solid wheel for a built wheel, and the machining of the driving faces, made the efficiency of the two wheels practically identical so far as could be calculated.

The sea trials of the President Pierce were carried out at 24 feet draught, the lowest at which the models were tested and the easiest at which to ballast the ship, with the loads arranged so that at the high runs of the standardization trial the draught would be as near as possible to the 24 feet and as near as possible to an even keel. The weather on the runs was good with very slight sea and light wind, so that there was no need to consider any correction from these conditions. The runs were made on the standard mile off the Delaware breakwater, and that course is rather shallow for a vessel of this size and speed, so there is probably some interference at the high runs. The depth on the course varies from 23 to 25 fathoms, but the straight way leading up to the mile buoy at each end is considerably shallower, being from 19 to 22 fathoms at the north end and from 15 to 21 fathoms at the south end, and this again may have caused some interference so that the speed obtained is probably not quite so good as it would have been on a deep sea trial.

Table of Auxiliary Machinery.

PUMPS.

Name	No.	Size	Type	Suction connection	Discharge connection
Main feed pump.....	2	21″ × 14″ × 27″	Vertical Simplex	6″ feed tanks 2½″ res. feed tank	5″ F. W. heater 5″ boilers
Auxiliary feed pump..	1	10″ × 7″ × 24″	Vertical Simplex	2½″ turbine drains 5″ feed tanks 2½″ res. feed tank 2½″ boiler	4″ F. W. heater 4″ boiler 2″ overboard 2″ res. feed tank
Ballast pump.....	1	10″ × 12″ × 12″	Horizontal Duplex	7″ sea 8″ ballast line 5″ bilge line	4″ overboard 6″ main condenser
Fire and bilge pump .	1	12″ × 8½″ × 12″	Horizontal Duplex	5″ sea 5″ bilge	4″ fire main 4″ overboard
Sanitary pump.....	1	8″ × 8″ × 12″	Vertical Duplex	5″ sea	4½″ distillers 4½″ sanitary system 3″ refrig. cond. 3″ water service
Engine-room bilge pump.....	1	5½″ × 7″ × 12″	Vertical Simplex	5″ engine room bilge 4″ bilge system	4″ overboard
Fire-room bilge.....	1	5½″ × 7″ × 12″	Vertical Simplex	5″ engine room bilge 4½″ bilge system	4″ overboard
Fresh-water pump....	1	7″ × 6″ × 10″	Horizontal Duplex	3″ F. W. tank aft. 2½″ eng. F. W. tank P. & S. 2″ dist. drain tank	2″ drinking water tank 2½″ 1,000 gal. tank 2½″ main feed tank
Drinking water pump	1	4½″ × 3¾″ × 5″	Horizontal Duplex	2″ F. W. tank 2″ dist. dr. tank	1½″ drink. water sys. ½″ eng. and fire rooms
Evaporator feed pump	1	7″ × 6″ × 10″	Horizontal Duplex	5″ sea 2″ cond. overboard discharge	1½″ evaporators 4″ san. sys., dist. and refrig. mach.
Auxiliary air pump ..	1	10″ × 18″ × 12″	Vertical Simplex	8″ aux. cond.	7″ aux. filter tank
Oil transfer pump....	1	8″ × 8″ × 12″	Vertical Duplex	7″ oil storage tanks 3½″ No. 5 hold, ford. and aft	6″ oil settling tanks
Fuel-oil service pump	4	7 × 4½″ × 10″	Vertical Duplex	3½″ settling tank	2½″ overboard 1½″ burners
Lubricating oil pump	4	8″ × 10″ × 14″	Vertical Simplex	6″ oil drain tanks	4″ oil gravity tanks
Oil cooler circ. pump	2	8″ × 10″ × 14″	Vertical Simplex	6″ sea	5″ cooler and overboard 4″ cooler and overboard
Brine pump.....	4	6″ × 6″ × 6″	Horizontal Duplex	4″ brine ret. tank	3″ brine cooler
Refrig.cond.circ.pump	2	6″ × 6″ × 6″	Horizontal Duplex	4″ sea	3″ refrig. cond.
Circ. hot-water pump	1	4½″ × 2¾″ × 4″	Horizontal	2″ hot F. W. tank	1½″ hot F.W. system
Lub. oil hand pump..	1	.....	.....	1¼″ oil drain tank	1″ filter and purifier
Aux. circ. pump.....	1	10″	Centrifugal	10″ sea	10″ aux. cond. 10″ overboard
Air pump.....	4	.....	Radojet	6″ main condenser	3½″ feed tank
Condensate pump....	4	.....	Centrifugal	8″ main condenser	4″ feed tank
Main circulating pump	2	10,000 G. P.M.	Centrifugal	19″ sea 14″ bilge	19″ main cond. 20″ overboard
Fuel-oil hand pump..	1				
Waste tank pump....	1	.....	Cent. Elec. Driven		

OTHER AUXILIARIES

Name	No.	Size	Type	Remarks
Main generator	4	50 K. W. 115 volt	Marine	Direct turbine driven, 3,000 R. P. M., exhaust-condenser, feed heater and atmosphere.
Fuel-oil heater	4	25″ dia. × 34″	12 coil 60 sq. ft. H. S.	
Fuel-oil meter	2	1½″	Worthington	
Forced-draft fan	4	42″ dia.	Turbo-vane	Capacity of each, 22,500 cu. ft. per min. against 3″
Injectors	4	2″	Double tube	
Evaporator	2	35 ton	Reilly	
Distiller	2	3,000 gal.	Reilly	
Oil cooler	4	350 sq. ft. H. S.	Schutte & Koerting	
Feed water heater	1	52″ dia. × 6′ 9″	.....	Capacity = 160,000 lbs. per hour, 90° F. to 212° F.
Air compressor	2	11″ × 11″ × 12″		
Oil purifier	1	.....	Centrifugal	
Aerating filter	1	13″	Reilly	
Ventilating fan	27	1,000 to 12,000 C.F.M.		
Winches	26	9″ × 12″		
Windlass	1	13″ × 13″	Spur geared	
Gypsy	2	10″ × 10″	Non-reversing	
Steering engine	1	16″ × 12″	Screw	

Plate 57 gives the tabulated results of these trials. The bottom table shows the results for the standardization at approximately 12, 14, 16 and 19 knots. It was intended to make five runs at the high speed, but the thirteenth run had to be thrown out on account of turn of tide, and this set was therefore split into two groups of three runs each. The speed results have been corrected for deviation. The shaft horse-power was obtained by means of Gary-Cummings torsion meters fitted to the two shafts next to the reduction gears, which were specially bored for the purpose, and the shafts were carefully calibrated in the shop with the torsion meters in place. The results of this trial are plotted on Plate 58, and alongside is a comparison of the effective horse-power and shaft horse-power.

In order to obtain some data as to the performance of the turbine, water-measuring tanks were fitted and arrangements made for measuring the steam consumption of the starboard turbines. Six-hour runs were made at approximately 7,000 and 10,000 shaft horse-power and a twelve-hour run at full power, and the consumption was measured for the whole time. A short trial was also made at about 10,000 shaft horse-power for the purpose of measuring the steam consumption of the auxiliaries. The data for these trials are shown on the upper half of Plate 57. It will be noted that the water rate is 10.70 at 13,043 shaft horse-power. The water is given uncorrected, except for a small allowance for Radojet steam. The consumption for auxiliaries showed rather high, 2.74 pounds, but this is a condition

which is partly inherent on a turbine ship and partly due to the extra auxiliaries needed in a passenger ship.

There is also shown, on Plate 59, the results of standardization trials on the President McKinley, and on Plate 60 the trials of the American Legion. These are both at a lighter draught than the lowest the models were tested at.

Both of these ships were built by the New York Shipbuilding Company, and the American Legion is fitted with wheels similar to those which were used on the self-propelled model.

The results of these tests have been presented as candidly and completely as possible, and it is hoped that they will be of value to the members of the Society. It is to be regretted that after spending so much time and money that the final results should fall so far short of what one would wish, because one of the ships was not standardized on a course of sufficient depth to obviate any guessing at the true speed in deep water.

The author wishes to acknowledge the courtesy of the New York Shipbuilding Company in furnishing the data on model tests and other information.

DISCUSSION.

MR. CHARLES F. BAILEY, *Member of Council:*—As Mr. Warriner stated, two of these vessels were built at Newport News. The general particulars of the vessels were the same as those built at the other yards; the machinery was somewhat different. The turbines were of the Newport News-Curtiss type, with slightly larger pitch diameters of the blades, and the condensers were somewhat different. The boilers were of the Babcock and Wilcox type.

I have a tabulation showing the trial results of the two vessels built at Newport News, as compared with those built at the other yards, as compiled in Mr. Warriner's paper (see Plate 61). The vessels built at Newport News were originally named Golden State and Silver State; these names were changed to President Cleveland and President Jackson.

The main condensers on these vessels were condensers not built at Newport News but inherited from the Shipping Board. They were built, we were informed, under war conditions. We found that they needed to be re-tubed and the internal parts reconstructed, but the design was not essentially changed. The condensers were constructed on the Lovekin principle. They were built by order of the Shipping Board by outside parties and were left over from cancelled ships. Worthington air pumps and Parsons augmentors were installed by us. The air pump discharge on these vessels during trials was only about 3° to 6° F. below the temperature corresponding to the vacuum.

The boiler heating surface amounted to 41,376 square feet, about the same as fitted by the Bethlehem Company. The boilers were fitted with Babcock and Wilcox oil burners. In this connection, I would refer to a statement on page 189 of Mr. Warriner's paper, to the effect that the burners of the President Pierce were of the navy type, and that on the subsequent ships the burners were changed to the Dahl type, which resulted in more favorable working conditions. I have the impression that other changes were also made coincidently with changes in burners, which might have affected the fire-room conditions referred to. It would be interesting to hear from Mr. Warriner as to this.

Through the courtesy of the New York Shipbuilding Corporation, I was present on the

trials of the American Legion, in which vessel the arrangement of the blowers is similar to that in the President Pierce, in which the blowers are of the vertical spindle type, as shown in Mr. Warriner's paper, and, I understand, take their suction from the deck above and discharge horizontally into the upper part of the fire rooms. This arrangement does not lend itself to a cool fire room, as was found on some of this class of vessels. In the President Cleveland class the blowers are of the horizontal type and take their suction from the ventilators above and discharge down the ventilators to the fire rooms, thus bringing fresh air down to the crew on the fire-room floor. This gives an efficient arrangement as far as ventilation and operating conditions in the fire rooms are concerned.

The temperatures are given in Plate 61 and are as follows:

President Jackson, 85° F.; President Cleveland, 80° F.; President Pierce, 113° F.; American Legion, 131° F.; and President McKinley, 94° F.

The air pressure during the trials of the Newport News vessels was less than on the President Pierce. The superheaters fitted in the Newport News vessels were of the Babcock and Wilcox type, and I would call attention to the temperature of the stack in these two vessels, which varied from 483° to 468° F., which is very good, and indicated efficient operation.

The President Cleveland was fitted with calibrated feed measuring tanks. There was a six-hour trial, and on the first four hours of the trial the steam consumption of the main turbines only was measured; on the last two hours the entire feed was measured, so as to give a line on the consumption of the auxiliaries. For the main turbines, during the first four hours, the consumption was 10.54 pounds as against 10.7 pounds given in Mr. Warriner's paper; and for the auxiliaries 2.46 pounds as against 2.74 pounds in Mr. Warriner's paper. The oil consumption measured by calibrated meters corrected to the basis of 19,000 British thermal units per pound was .935 pound and .941 pound respectively on the two Newport News-built ships.

I might say that these trials were run off the Virginia Capes in water of from 7 to 15 fathoms. A comparison of data from sister ships of approximately the same displacement on trials run off the Virginia Capes in one case, and the Delaware Breakwater in the other, indicates that from 4 to 10 per cent more power is required for the same revolutions on trials off the Virginia Capes due to the shallow water. The trials of the President Cleveland were run five days after the vessel was docked, and the trials of the President Jackson twenty-two days after docking.

I wish to say something about the gears, on which very little data are given. The gears fitted in the two Newport News ships were about the same diameter of main gear and pinion as were installed in the Bethlehem Company ships, but with more face, the Newport News ships having 42 feet face as against 36-feet face of gears fitted in the President Pierce.

I would like to state that the contract speed of these ships was 16 knots. The machinery was guaranteed to make 12,000 horse-power. We all understood and knew that this power would drive the vessel at more than 16 knots. A few days ago I was informed by one of the Shipping Board Commissioners that several of these ships are making over 18 knots sustained sea speed. I informed the commissioner that we would not advise operating these gears at this power, as we believed that they would not be entirely satisfactory if so operated in continuous service.

I think it would be interesting to hear from Mr. Warriner as to the cast steel main gears which were fitted in the President Pierce, and to be informed if these gears are giv-

ing entire satisfaction. We fitted in the ships at Newport News nickel steel pinions with gears having carbon steel rims.

It is important in all vessels of this type to make the fire rooms comfortable and arrange the boilers to be easily cleaned so as to maintain their efficiency. We all know that when out on trials we see to it that the boilers are clean.

The Society is fortunate in having this paper presented by Mr. Warriner.

MR. E. H. RIGG, *Member of Council*:—It is very gratifying to see that the paper read before the Society last year on the "Design and Construction of Passenger Ships" has been amplified by Mr. Warriner's paper this year. Each paper renders the other of more use to the members of the Society.

One point brought out clearly by Mr. Warriner's analysis of the President Pierce (Hawkeye State) trials is the discrepancy between expected and realized performance.

Plate 58 brings this out, showing an increase of about 12½ per cent in power for the ship as compared with the self-propelled model test at 19 knots, which means a decided drop in propulsive coefficient, also shown by the charts given.

There are several points to be examined here; the following are perhaps the most pertinent:

1. Difference in propellers as noted in the body of the paper (page 190): This cannot conceivably account for more than a small amount of the difference (see Plate 56).

2. Depth of water on the course. The battleship Michigan comparative trials at Rockland and Delaware Breakwater showed that the increase of power below and at 18 knots was trifling, but was clearly perceptible at 19; this at the same draught of ship that we are considering. Depth of water cannot be considered a serious factor in this case. The power realized on trial is high all the way up the curve and does not suddenly increase at the top speeds.

I want to guard against misunderstanding right there. The preceding paragraph refers only to the measured mile course and does not refer to the endurance runs outside in shallow water; this is a point which occurred to me when Mr. Bailey was speaking, namely, the depth of water on the course is one thing, and the depth of water outside in the vicinity of the Delaware Capes is another thing.

The figures for the Michigan are as follows:

Course.	*18 Knots.*	*19 Knots.*
Rockland, Maine	13,325 I. H. P.	16,880 I. H. P.
Delaware Breakwater	13,525 I. H. P.	18,300 I. H. P.

The Michigan is 450 feet long, 16,000 tons displacement and 24 feet 6 inches draught, but of wider beam; namely, 80 feet.

These results are as recorded in the Journal of the American Society of Naval Engineers, Volume 22. The two curves were practically identical up to 18 knots and then separated as noted above. This was not the case with the Hawkeye State (see Plate 5). These comparative courses trials were conducted under navy standards, which means care, accuracy and intelligence as far as the human machine is concerned.

3. The recent absence of proper range buoys on the Delaware Breakwater Course may possibly have affected results, but with care and experience the true course can be run and

probably was run in this case. It is important to make sure, by cross bearings, that the vessel runs through the deep water, which is limited in extent, in both directions. It is important also to be sure that the ship is not accelerating when entering the mile, a difficult matter with no buoys.

Torsion meters may have read high; there have been several instances lately where these instruments have given readings very disappointing to designers and builders. On the occasion of the recent trials of an electrically driven ship the torsion meters were high as compared with the electrical instruments, as well as with the self-propelled model results.

The time out of dry dock is not mentioned, that I noticed, but it is probable that the ship was docked, cleaned and painted very shortly before the trials. This time might well be given before final printing of the Transactions.

One troublesome point is absent here; Mr. Warriner tells us that the sea was calm and the wind light. These vessels have high superstructures, and it is probable that there is an addition of the order of 2 to 2½ per cent to be made to the model tank shaft horse-power at 19 knots even in still air, the exact amount being difficult to assess.

Those interested are referred to Commander W. McEntee's paper read here in 1916, to Mr. W. W. Smith's paper in 1917, also to Admiral Taylor's classic manual on "Speed and Power of Ships," 1910. The hull form offers very little air resistance, but the houses, masts, etc., in large passenger ships should be allowed for. In the *Engineering* (London, 1907) accounts of the Mauretania's design, this point is also emphasized.

Mr. William W. Smith, *Member:*—There are one or two things in connection with Mr. Warriner's valuable paper that I think can be brought out. Mr. Rigg has already emphasized the fact that the horse-power on the trial course exceeds the estimate results from the self-propelled model test by about 12.5 per cent.

Referring to the test on the President Pierce, given by Mr. Warriner for a speed of 18.08 knots, the following additional data have been worked out.

The propulsive coefficient for this speed is 59.8. The superheat referred to by Mr. Bailey is 41° F. The ideal water rate, on the Rankine cycle, for the steam conditions on that trial is 6.9 pounds per horse-power. The efficiency of the turbines referred to the Rankin cycle is 64.5 per cent. The steam consumption of the auxiliaries in per cent of the turbine steam consumption is 25.6, and in per cent of the total steam consumption is 20.4.

If we allow a boiler efficiency of 74 per cent, which is conservative, and take 19,000 British thermal units per pound for the fuel, the fuel consumption per day works out as 139.7 tons, and per shaft horse-power per hour, 1.0 pound. The actual evaporation per square foot of heating surface is 4.38 pounds. The cooling surface of the condenser per shaft horse-power is 1.11 per square foot. This, of course, is satisfactory for temperate water conditions, but I think it is somewhat low for tropical conditions. At any rate, we usually allow from 1.45 to 1.5 square feet per shaft horse-power for tropical conditions, where the temperature of the water is taken as 85 degrees.

I am informed that the total weight of the machinery for this installation is 1,040 tons, wet, which works at about 180 pounds per shaft horse-power.

Referring also to Plate 57 which gives the trial of the President Pierce, it is noted that the vacuum as recorded does not agree with the exhaust chamber temperature. In one case, the exhaust chamber temperature is recorded as 100.8 degrees and the vacuum as 28.8 inches. The vacuum corresponding to this temperature is 28 inches, which makes the vacuum

reading 0.8 inch lower than the temperature reading. In another case, the vacuum corresponding to the temperature is 28.53 inches, whereas the recorded vacuum is 28.8 inches, which is 0.27 inch lower. On Plate 59 the vacuum corresponding with the temperature agrees exactly with the recorded vacuum.

Admiral C. W. Dyson, U. S. Navy, *Member of Council* (Communicated) :—The great point which stares the reader of this paper in the face is the large discrepancy between the shaft horse-powers for the different speeds as obtained from the Model Basin trials and those obtained on the actual trials of the vessels.

Why this discrepancy? In the paper the author hints at the possibility of the trial course depth being the cause. I cannot agree with him as to this. I ascribe the entire trouble to the character of the hulls. These hulls are extended in the quarters to form a casing in which the propeller shaft is carried, and these casings extend clear aft to the bosses on the struts. The structure varies from about 5 feet in the external width at the forward end to the diameter of the strut boss at the after end. The depth is not shown on Plate 55, but it is sufficient to carry the stern tube and stuffing box and one coupling and one line bearing and must have clear area enough to give access to these.

In my experience I have encountered several vessels where horizontal interferences to vertical flow of the water closing in around the stern of the ship exist, and others where these interferences have been with the horizontal flow of the closing-in water. In the former cases, with the interference extending clear out from the hull of the ship to the propeller shaft, as in the case of a spectacle frame with horizontal fin, the effect has been beneficial, the propeller being slowed down in revolutions and the "Loss Factor" K becoming VK. In the second case, however, where the horizontal flow is interfered with, incipient cavitation occurs due to the bad quality of the wake between the interfering member and the hull, speeding up revolution where the basic slip is 13 per cent or less, and causing K to become K^2.

As Model Basin trials do not give any indication of cavitation, of course, the results obtained by running the self-propelled model are those which may be expected when neither incipient nor full cavitation occurs.

I have analyzed the propeller performances of the President Pierce and of the American Legion on the assumption that incipient cavitation is actually occurring, and in place of K have used K^2.

I include herewith these analyses and call your attention to the close agreement between estimated powers and revolutions and those obtained on the actual trials (page 198).

Mr. Alfred J. C. Robertson, *Member*:—Gentlemen, as you are no doubt aware, four of these ships have been on the South American route of the United States Shipping Board and operated under the Munson Steamship Line. I have had access to the logs, and it would have been a very great pleasure if I could, from these, give you really reliable data as to the performance of these ships. I have gone over the logs very carefully, but anyone who has not looked over logs of that kind, and gone into them a little bit, will realize how difficult it is to eliminate the various things which will prevent us getting reliable figures.

These boats run on a schedule; the first day after they leave port they are retarded in their progress for various causes. Then they cross the Gulf Stream and later on get into the tidal streams of Cape Roque, so that altogether their sea speeds do not correspond in any way to measured mile conditions.

PROPELLERS—CHARACTERISTICS AND BASIC CONDITIONS.

Ship.....	*President Pierce*	*American Legion*
D.....	16.5	17′
P.....	17′	18.5
P. A. ÷ D. A..	.3246	.315
T. S.....	7210	7030
$I-S$	.8675	.8675
V.....	20.24	20.85
S. T.$_D$	3.9	3.68
S.H.P.	17,208	17,751
P. C.	.723	.756
E. H. P.....	12,441	13,420

ANALYSES OF TRIALS.

	President Pierce				*American Legion*			
V.....	12	14	16	19	12	14	16	19
e. h. p.....	2000	3150	4600	8000	2000	3150	4600	8000
$\frac{v}{V}$	.5928	.6916	.7904	.9386	.5756	.6715	.7675	.9114
e. h. p. ÷ E. H. P..	.1608	.2532	.3698	.643	.149	.2347	.3428	.5962
Z_p	−.825	−.62	−.45	−.2	−.86	−.658	−.482	−.237
K	1.135	1.135	1.135	1.135	1.135	1.135	1.135	1.135
K^2.....	1.288	1.288	1.288	1.288	1.288	1.288	1,288	1.288
Z_g	−.716	−.510	−.34	−.09	−.750	−.548	−.372	−.127
S. H. P.$_d$	3317	5318	7865	13987	3157	5026	7537	13250
Act. S. H. P.$_d$ ...	3100	5000	8000	13300	2950	4900	7650	12850
Z_s	.577	.38	.214	0	.615	.42	.252	.035
*s	.09013	.09236	.1008	.1024	.09075	.09621	.102	.104
R_d	78.61	91.94	106.1	126.2	72.29	84.85	97.59	116.2
Act.....	76	94	102	127	72	84.5	98.3	115.5

*By using actual power developed.

The American Legion has averaged 19.3 knots on a 24-hour run north and 24-hour run south at a draught of 23 feet 2 inches. The Southern Cross averaged 19.87 knots on a draught of 22 feet 5 inches. The Pan America averaged 19.3 knots, and the draught was 20 feet 9.5 inches. The Western World averaged 20.0 knots on a draught of 27 feet 6 inches.

After correcting these figures for tidal influences (which, on the best runs, average about three-quarters of a knot), the American Legion has averaged 18.40 knots sea speed for forty-eight hours on 23 feet 9 inches draught, with 110.8 revolutions per minute.

The Southern Cross has averaged 18.48, with 22 feet 10.5 inches draught on 112.5 revolutions.

The Pan America on 24 feet 1¾ inches draught, with 121.4 revolutions per minute, averaged 17.85 knots.

The Western World on 27 feet 7½ inches draught, at 121.9 revolutions per minute, averaged 18.4 knots.

The American Legion and the Southern Cross, I should explain, are of the double-reduction gear type. The Pan America and the Western World are of the President Pierce type, with single-reduction gears, and taking these two pairs of ships, we get the American Legion type at 18.44 knots, 111.65 revolutions per minute, and 23 feet 4 inches draught, and the Pan America 18.13 knots on 121.6 revolutions per minute, and 25 feet 10¼ inches draught.

The mean slip for all the voyages (eliminating one or two cases, where the figures were questionable) for the American Legion, Pan America, and Western World is 11.5 per cent, and for the Southern Cross it was 12.5 per cent.

The oil consumption for all purposes, so far as we could measure the shaft horse-power (we have no torsion meters in use), for the American Legion is 1.055 pound, and for the Southern Cross 1.13 pound, making it 1.084 pound for both of these vessels; for the Pan America it is 1.13 pound, and for the Western World 1.03 pound.

It should be added that these fuel consumptions include the fuel used to maintain a very extensive electrical installation and also a considerably increased refrigeration plant.

Mr. J. T. Dalcher, *Member*:—Mr. Warriner's paper gives a good account of the general design, estimated performance, model experiments and actual trial performance of a type of machinery installation that has been of special interest to marine engineers, being of a higher type than that usually installed in this country for commercial vessels.

The trial reports regarding speed and horse-power agree very closely with the results obtained from the model experiments. In my opinion, the added expense of such experiments is well worth the information obtained therefrom and should be encouraged wherever possible, as they are very valuable as a basis of comparison with the calculated performance. The machinery installation described in the paper is designed with a view to obtain the best results possible and still keep within conservative limits regarding reliability and simplicity of design and operation.

The adoption of the water-tube boilers is to be specially noted, and it is hoped that the boilers will continue to give a good account of themselves in service. The adoption of this type of boilers for vessels of purely commercial nature is to be welcomed as opening the way to more efficient means for generating steam, thereby tending to improve the overall efficiency of the power plant, improving the flexibility of operation and allowing a reduction of weight and space as compared with the conventional Scotch boiler.

The successful operation of these passenger vessels has no doubt fully established confidence in this type of machinery, and I am looking forward to further improvements on future passenger vessels, such as the adoption of higher superheat, higher turbine efficiency and a step forward in the development of a higher and more efficient type of auxiliaries which will compare more favorably with the efficiency of the propelling machinery proper.

Admiral David W. Taylor (C. C.), U. S. Navy, *Honorary Vice-President*:—This is one of those papers which is of permanent value,and we always delight to welcome such papers in the discussions of the Society. There is an enormous amount of data which has been given in the paper, and it supplements exceedingly well Mr. Rigg's paper, dealing more par-

ticularly with hulls rather than the machinery. I am not going to discuss anything except one feature of the paper, which renders it of particular interest to me, because it shows a discrepancy or failure to agree with results estimated at the Model Basin.

The discrepancy has been stated as 12.5 per cent; that is correct at 19 knots, but if you will state it at a lower speed, it is something of the order of 15 per cent; and if the Model Basin cannot come any closer than that, it is hardly worth working.

This is not the first time that model-basin results have been compared with full scale experiments.

During the last few years since the Model Basin has been able to test models, self-propelled, it has compared a number of estimated curves of horse-power with actual curves of horse-power, in the case of naval vessels, and I took particular pains the other day to inquire as to their experiences. They have had something like eight or nine cases, I believe, of vessels which they have tested, ranging from battleship to torpedo destroyers and auxiliaries, and in every case the agreement has been very satisfactory—of the order of a few per cent—it would be suspicious if it were exact, owing to the nature of the case.

Perhaps I should make one exception to that. It is with regard to destroyers. Up to the speed of 30 knots, or a little below, the deductions from the model self-propelled trials are in agreement with the actual curves of shaft horse-power. From 30 knots up they do not agree. We have always ascribed this latter disagreement to incipient or mild cavitation. At higher speeds there is a discrepancy undoubtedly due to cavitation; that applies only to torpedo-boat destroyers at the high speed.

Let us consider these curves in a little detail. In the first place, referring to Plate 58, the curves at the left compare the curve of shaft horse-power with that deduced from tests with models, and in these tests I understand the model represented a ship complete, that is, it had all the appendages. The actual curve as drawn seems to tend rather to get together at 19 knots. I think that is probably because the 18-knot spot may have been a little low, so considering the curve as drawn, the upper part looks to me too straight. If you will go down a little further at 18 knots, you will see the discrepancy is about 1,500 horse-power, or practically 15 per cent.

I am somewhat of a crank on cavitation, and the first thing I suspected was cavitation, but I am sorry to say that I cannot agree with Admiral Dyson in ascribing this trouble to cavitation. If you will look at the right-hand figure in Plate 58, the curve of slip, you will find the slip on trial was not only very moderate but showed no tendency to increase above 15 knots, and so far as I know, whenever cavitation is present, it is necessarily and inevitably accompanied by abnormal increase in the slip. So I am sure that we will have to absolve cavitation as the term is commonly understood.

There was a remark made by one of the speakers as regard to accuracy of the recording gear. The results seem quite consistent, but it is practically impossible to prove anything about it one way or the other.

I used to believe, when I attempted to analyze trials with reciprocating engines, that the indicator did not give a result which could be counted on within 5 per cent. I rather doubt whether the torsion meters give any better result than the indicator, but at least they give consistent curves.

Anyone who attempts to analyze curves from the original data will find in practically every case that the data require some explanation. That is the case here, in a relatively minor matter.

If you consider the plate giving the details of the trial of the President Pierce from the economy standpoint, you will find at the left hand of the plate, at the 15.4 knot speed, the average revolutions were 101.7, and the two powers added together 7,110.

Take the next line below, speed not given; average revolutions 102.9, and the power 9,565, an increase of 2,400 in the power for 1.2 revolutions. That was probably due, I should say, to the question of depth of water. It is very likely that the high power was run in unusually shallow water, but that is the kind of thing we always run against when we attempt to go back to the original data in test trials.

Another factor in connection with trials is the question of a steering. We were told yesterday that bad steering would add to the resistance 16 per cent. I do not know whether the steersman in these trials is guaranteed but maybe that will account for the whole difference.

In regard to the depth of water, I think there is no question it must have had some effect, but if you take Rota's results, which are perhaps as good as any, on that, you will find, according to him, there will be practically no increase in resistance up to 13 or 14 knots, and that the increase would be comparatively low, probably for a knot or two beyond that; and as we find there is quite a discrepancy between 13 and 14 knots, there seems to be little question that the depth of water could not account for the whole difference, although it was one factor.

You will find, if you plot the power upon the revolutions instead of speed and plot the economy runs as well as the speed trials, while the power for various revolutions seems somewhat erratic, particularly the one speed I have referred to—generally speaking, the economy run falls fairly close to the standardization run, though I understand that the economy runs were made in much shallower water. If the runs on this course and in much shallower water agree, it is rather a reflection upon the accuracy of one or the other.

Let us consider the problem in detail for a minute. Curve B in Plate 58, again, is not deduced from experiments with the President McKinley model. It was deduced from experiments with the model of the American Legion, with a different propeller. Although, as pointed out by Mr. Warriner, the difference is probably due to lack of smoothness of the propeller of the American Legion, and that might make up partially for the smaller size and smaller pitch ratio of the propeller of the President McKinley, that would not apply to the model experiments. In the model experiments the propeller of the American Legion was undoubtedly just as smooth and carefully finished as it would have been if it had been the model of the President Pierce, so that that is another factor, all tending in the same direction.

Now we come to the question of the condition of the bottom. I would like to ask Mr. Warriner how long the vessel has been out of the dry dock?

MR. WARRINER:—Something like two weeks.

ADMIRAL TAYLOR:—The President Pierce was in practically fresh water. How long had it been in the fresh water?

MR. WARRINER:—Five days.

ADMIRAL TAYLOR:—We have had some experiments recently in the matter of the fouling of ship's bottoms which brought home to us more than ever the fact that this fouling is

a very important question, and it appears that a short stay out of the dock, without any apparent fouling, may have an appreciable effect on resistance. That matter is being investigated, and I hope we will get at the bottom of it in time. Two weeks is not a very long time, but that is another factor working in the same direction.

A thing in this paper which excited my curiosity more than anything else was Plate 56. Take the right-hand diagram in Plate 56—the upper curves of propulsive coefficient—you will see the upper curve *c*, which applies to the 16,000-ton condition, is decidedly above the others, reaching a maximum a little under seven-tenths. The next curve falls off materially until deep top load curve is quite a bit below 65. That seemed to be rather a large difference, and I inquired at the Model Basin and obtained some information which I hope that Mr. Warriner will get and add to his paper.

The wake factors in the three conditions appear to be practically the same. There is a slight difference in the thrust deduction coefficients, the thrust deduction coefficient increasing as the draught increases, but not enough to account for the difference; and if you will examine curves of slip corrected for wake, you will find that the upper curve *c* corresponds to an actual slip of the propeller of about 20 per cent, and the lower curve *a* corresponds to an actual slip of about 30 per cent; in other words, the propeller is working well on the down grade, from the point of maximum efficiency.

I think in this case, as well as in the majority of cases of actual ships, the revolutions of the vessel are too high to get the highest possible propulsive efficiency. As we all know, it is very hard with modern machinery to get it to turn slow enough to get a really efficient propeller, that is, to get the maximum efficiency of which the propeller is capable. Change in the revolutions of the President Pierce, from 110 to 125, which was necessitated by gear considerations, is also a cause for decreased efficiency, and I am rather inclined to suspect, if the President Pierce propeller were actually tested in the model, its efficiency would be less than estimated by the author.

The previous factors which I mentioned are all on the side of increased resistance, such as fouling of the hull, shallowness of water, etc. An increase in resistance of the ship will necessarily add to the slip, and the efficiency will slide on down, the effect being more or less cumulative. I believe that this discrepancy of 15 per cent is accounted for by a number of small causes which would have been discovered if the model had been tested in the Model Basin under actual conditions of trial. There is no difficulty in testing a model in the Model Basin in shallow water. I was a little surprised, in view of the conditions, to hear the statement as to the wonderful speed made by one of this class at sea, because if we have to increase the power at sea to cover an average increase of say 20 per cent over the trial trip conditions, the propeller would have undoubtedly worked under exceedingly inefficient conditions. That is a case where, if you make a larger propeller, there is no question you would get somewhat better results on trial, and perhaps much better results at sea.

Probably a four-bladed propeller would show even greater improvement. If you make a larger propeller, you necessarily slightly reduce the pitch ratio, and the result would be, in my mind, to slightly reduce the upper comparative curve of propulsive efficiency in Plate 56 and materially raise the lower curve; in other words, to bring the curves of propulsive efficiency close together, as they should be.

MR. BAILEY:—I think that Mr. Warriner's paper, together with the discussions, form a valuable contribution. I would like to inquire if Mr. Robertson could not give to the

Society data (1) as to the fire-room temperatures of these vessels which are being operated by the Munson Line under his direction, and (2) supply a statement of the condition of the gears. We all know that at 18 knots speed the gears are heavily loaded, and it seems that to complete this paper such data would be of the greatest value.

I would state that on the President Cleveland the power was measured by Hopkinson-Thring torsion meters, and as far as we can see from the tabulated data, the results correspond quite closely to the other vessels.

MR. ROBERTSON:—In reply to Mr. Bailey's inquiry, I would say, in regard to fire-room temperatures, that in the last two ships, Pan America and Western World, it was decided to run on natural draft under ordinary conditions, and the changes involved have reduced fire-room temperatures about 40 degrees below those in sister ships. This change is therefore also contemplated for the American Legion and Southern Cross.

The reduction gears in all four ships are standing up perfectly, and with the exception of one pinion, none of these gears have required attention. The one pinion referred to was somewhat noisy and was rehobbed when the ship was being overhauled.

MR. WARRINER:—In the first place I wish to thank those gentlemen who have taken part in the discussion of the paper and will endeavor to give the additional information requested.

Mr. Bailey has presented a tabulation of the trial results on five of these vessels.

In the case of the President Pierce, the water rate is uncorrected. There is some doubt as to the steam temperature at the turbine steam chest, but assuming similar conditions to the other ships, the water rate for the starboard turbines corrected to 250 pounds gauge chest pressure, 75° F. superheat and 2″ Abs. vacuum would be—

	Pounds.
Full power	10.3
Intermediate power	10.92
Low power	11.75

These turbines were designed to meet a guaranteed water rate of 11 pounds. Those for the President McKinley and also for the President Cleveland and President Jackson were designed for a guaranteed water rate of 10.5 pounds per shaft horse-power.

On the trials of the President Pierce the blowers were located over the backs of the boilers. They were changed to over the fire rooms with a considerable improvement in the fire-room conditions. As mentioned in the paper, the last two ships were fitted with Dahl burners and are operating continuously on natural draught, the air coming down right in the middle of the stokehold, which makes them quite comfortable and allows of easy operating conditions.

Full particulars of the gearing on these ships were given in my paper, "Reduction Gears for Ship Propulsion," Transactions of the Society of Naval Architects and Marine Engineers, 1921.

The solid steel gears are quite satisfactory and give every indication of being a lasting proposition. We have fitted a large number of this type, manufactured by the Falk Company, and so far have had no failures.

It is believed that these solid gears, when properly cast and when made of the right

kind of material, are superior to the built gears. They are lighter and are free from internal stresses because they are twice annealed during the process of manufacture and are made with split hubs. The bore of the hubs is finished after the second rough machining and just previous to the finishing cut over the rim. Experience shows that these wheels keep their form and continue to run true.

With reference to the remarks of Mr. E. H. Rigg and Admiral Taylor, the following shows the dates for docking and trial trips on the American Legion, President McKinley and President Pierce:

Vessel.	*Date of coming out of dry dock.*	*Date of standardization on trial trip.*
American Legion	16 June, 1921	8 July, 1921
President McKinley	18 April, 1921	26 May, 1921
President Pierce	5 January, 1921	17 January, 1921

In the case of the President Pierce, the vessel lay in the stream for two days previous to the trial for the purpose of taking on ballast.

As pointed out, the difference between the shaft horse-power as estimated from the model test and the actual obtained on the trials is quite large, and it seems rather difficult to explain away the difference. The shafting with torsion meters in place were carefully calibrated, and a survey of the records both at the time of the trials and since fails to show anything wrong with the shaft horse-power as calculated from the meter readings. The torsion meters were on the line shaft next to the gears, and as the shafting is fairly long there would be a loss between the torsion meter and the propeller. This has been estimated and the percentage of power delivered at the propeller would be 96.37 per cent at 12.31 knots, 97.06 per cent at 14.31 knots, 97.48 per cent at 16.07 knots, and 98.2 per cent at 19 knots. These figures should be regarded as a maximum, and the normal loss might be expected to be half of these amounts.

The self-propelled model was tried with all appendages, but the hull would be smooth, whereas the hull of the ship has projections for the laps and joints in the plating, rivet heads, under water fittings, etc., and probably some 2½ per cent should be added to the horse-power as found from the model test to allow for this additional resistance. Also, as Mr. Rigg points out, there would be some air resistance, which it is difficult to estimate.

We also have the knowledge, as Mr. Alfred J. C. Robertson pointed out in his remarks, that these ships are making excellent time at sea, at displacements equal to or greater than that used on trial, which would confirm the idea that there was some interference due to the depth of water on the mile. In the case of the President Pierce the economy trials were run in varying depths of water, but mostly in shallow water near the Virginia Capes.

Admiral C. W. Dyson has supplied an interesting discussion on the propellers of these vessels, but has apparently assumed that all the ships were run at the same draught. Plate 62 shows curves for the President Pierce, President McKinley and American Legion in the form of a correction factor as applied to the self-propelled model results as against the actual power on trials. The shaft horse-power for the self-propelled model has been obtained for the corresponding displacements of the three ships by plotting cross curves. This would indicate that the President Pierce propeller shows a better efficiency than the other two and points the advantage of the solid propeller with machine driving surfaces.

Mr. William W. Smith calls attention to the discrepancy between the temperature re-

corded at the exhaust chamber and the vacuum, but it should be noted that on these trials the barometer stood at 30.62 inches, which would explain most of the difference.

THE PRESIDENT:—You can see by the applause, Mr. Warriner, that your paper has been very thoroughly appreciated, and on behalf of the Society I wish to extend the thanks of the members of the Society to you for the pains you have taken to prepare such an admirable paper.

The next paper, gentlemen, is No. 11, entitled "Standardization as Affecting the Shipbuilding Industry in the United States," by Mr. E. H. Rigg, Member of the Council of the Society.

Mr. Rigg presented the paper.

STANDARDIZATION AS AFFECTING THE SHIPBUILDING INDUSTRY IN THE UNITED STATES.

By E. H. Rigg, Esq., Member of Council.

[Read at the thirtieth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 8 and 9, 1922.]

During the last two decades there have been many converts to standardization; it has made stronger headway in fields other than shipbuilding, and there is almost no one today who will deny the value of the general principle. It is when you come to apply it to concrete cases that difficulties arise. Without standardization, shipbuilding, as we knew it during the war, would have been impossible; the question is therefore on the extent to which it shall be carried rather than on whether or not standardization shall be adopted.

Engineering standards have been a recognized necessity for many years, though it is only comparatively recently that they have reached their present status and extent in the engineering world.

We are partly taken care of in shipbuilding standardization by such bodies as the Federal Bureau of Standards, the American Bureau of Shipping, the U. S. Steamboat Inspection Service, the American Society for Testing Materials, the American Engineering Standards Committee, also the Treasury and Navy Departments. The Navy Department is mentioned here last merely because this paper mainly deals with merchant shipping. On navy work, navy standards are naturally paramount, and their influence also extends into merchant work in yards doing both kinds. Owing to the service conditions under which warships operate, these standards are generally more exacting than those governing merchantmen.

Apart from the well-known and long-established classification societies, there is a relatively new body of this nature that bears on our business to a considerable extent, namely, the British Engineering Standards Association, whose work in standardizing specifications for structural materials, products and fittings entering into ship construction is decidedly more far reaching than anything we have; however, as noted above, we are by no means without similar bodies.

Standardization is a large subject. The deeper one gets into it the larger the possibilities, and, as would be expected, the more impressive the difficulties.

A paper on this subject read before the North East Coast Institution of Engineers and Shipbuilders by Mr. C. leMaistre, secretary of the British Engineering Standards Association, in March of this year, is both interesting and informative. One among many interesting points brought out is to the effect that standardization has reduced steel costs of production by at least 5 shillings (nominally $1.25) per ton; such points effectually nailed down as proven will do more than many sermons to convert the skeptical. A study of this paper will well repay those interested and will also show the standing which standardization has already attained in shipbuilding abroad.

An extremely interesting test of the value placed on standards is to ask one of our yards to build a vessel using Whitworth standard screw threads throughout. It looks fairly

innocent at first, but wait till you begin writing to the makers of the auxiliary machinery, to say nothing of your own machine shop's feelings in the matter!

STANDARD SHIPS.

Taking standardized ships first, as distinguished from variegated ships built from standard parts: during the war we built many such standard ships; the Hog Island, Submarine Boat Corporation and Great Lakes numbers and types of standard cargo vessels stand out preeminently as the biggest efforts along those lines. There were also other standard cargo types, but these were built in fewer numbers. The vast numbers of submarine chasers are another instance, also the large number of destroyers built for the Navy.

The cargo vessels above referred to were laid down to meet a war need, it is true, but they remain distinct from the strictly naval vessels. As one effective answer to the submarine campaign of the enemy, they, without doubt, fulfilled their object. The 7,825-ton Hog Island boats are a more generally useful type than the submarine boat 5,075-tonners or the Great Lakes 4,200-ton steamers, useful as these smaller vessels are in such localities as the Baltic and on the short-run trades.

That we shall again witness such an effort is not probable; further, that this effort has helped to put a quietus on general cargo vessel construction for some time ahead is also to be admitted. As an example of standardized work which justified its conceivers, there is no doubt that it did more than make good; while there were differences in detail in these groups, such minor variations did not alter the status of the ships as standardized products. These detailed differences sometimes indicated progress, but were in many cases unjustifiable and extremely annoying to the builders; they serve to emphasize one of the main arguments against standardization, namely, that it prevents progress. Automobiles are standardized, but that does not prevent improvements being made in the 1922 over the 1921 model. In the same way, succeeding ships for a particular trade can and do embody improvements over the earlier ones.

The situation for standard ships would appear to be as follows: In emergency, when large numbers of ships are wanted in a hurry, by all means build to a standardized design. When all are building in one yard this holds absolutely; when building in several yards it holds in general, with the qualification that each yard should be allowed to adhere to its own general way of doing business and to work to the same general plans and specifications in its own way, with freedom as to details. This can be qualified to say that full consideration should be given to a yard having plans, etc., available for a vessel substantially equivalent to the proposed standard ship.

Main and auxiliary machinery should be common to all ships of the type and therefore interchangeable from ship to ship to a very large extent; this has helped deliveries frequently when a broken part in an earlier ship can be taken from a later vessel.

As a normal proposition, wholesale standardization of complete ships is not to be looked for. It cannot be denied, however, that there are so many tramps of certain deadweights as to very closely approximate standardization. The large class of 7,000 to 8,000 tonners is worth noting, even though we have variety in detail to suit different builders' and owners' ideas.

When repeat orders are given for a vessel already built, the work is thus partly standardized. There are many instances of this on record; a type proves satisfactory in service

and may be repeated at intervals in groups as many as fifteen or twenty times, with only minor and detail changes. The work is thus spread over a period of years, so that the advantages due to repetition work in the shops do not enter into the consideration. The main advantage is in time, because the design, plans, material-orders and specifications are immediately available.

Oil and cargo ships come in the repeat-order category rather than passenger ships. The Shipping Board 535-foot passenger ships were an example of a large number of ships laid down to the same original plans as troopships, but finished up in groups for several lines and services as passenger ships. The hulls were practically identical, but even here changes were made to get different oil-fuel capacities; the machinery was built in groups to spread the work to different boiler, turbine and gear plants, so there was only partial standardization in machinery. The passenger accommodations were most wide of "sameness." While it is misleading to say that no two ships were alike, it is fair to say that with sameness of outline plans we have very considerable differences in detailed arrangements and decorative schemes, so that these differences finally resulted in a fleet wherein there were greater or lesser differences in every ship. Arguing from this and from general experience, standardization of passenger ships may be dismissed from serious consideration, except in quite small groups. Shipbuilding, in the nature of things, does not lend itself to standardization as a whole, but to build large ships in groups of limited numbers, suitable to particular trades, is a practice as old and older than anyone living today.

There is a large field where more has been accomplished than meets the eye on first approaching the subject, namely, international agreements on such matters as rules for avoiding collisions; signal codes; tonnage laws; lifeboats, and subdivision of passenger ships. Working agreements between classification societies in different countries tend toward broad-gauge standardization. Standard load-line regulations are well on the way to international scope. Agreement to recognize each other's inspection certificates covering passenger and crew accommodations between countries having substantially the same regulations is another step towards the common goal.

The tendency towards international codes covering the fundamentals of shipping both as to building and to operating is right and proper, particularly when it is remembered that the high seas are world wide and provide highways common to all nations. The sea does not ask if a ship be American or French, but treats them all alike; hence the growing volume of international standardization of fundamentals is to be welcomed and helped as a means of getting along better with international intercourse and trade.

STANDARDIZATION OF MATERIALS.

Turning to the standardization of parts entering into ship construction, we find much to study. We also find great progress to record. We even find some progress towards international standardization, though this phase of the problem has naturally not progressed nearly as far as international covenants covering broad principles.

Consider the steel of which ships are nowadays constructed. Wood, iron and concrete need not be considered here, because merchant shipping today is, to all practical intents and purposes, universally constructed of steel.

International specifications for ship steel have not yet arrived in spite of efforts which were under way when the war broke; the difficulties are great, and they begin in the mines

where different ores have different characteristics and properties. A universal specification is difficult to draw that would avoid undue favor to some mills as compared with others. American, British and German steels have their own characteristics, but given a willingness to cooperate, it should not be impracticable to draw specifications broad enough to cover a merchantable article satisfactory for use the world over. One great question is: Can genuine willingness to agree, if possible, be obtained? Without at least that as a basis, it is no use trying for international steel standards.

During the war, considerable progress was made towards international standard rolled sections, such as angles, channels and bulbs; this as between America and Britain. Here we have two standards, structural shapes and ship shapes, these ship shapes being identical with the British except in minor points; there they have one set of standards for bridges, buildings and ships. There is considerable opinion in favor of a single standard here. The manufacturers fear scrapping of equipment before it is worn out; the answer is that properly regulated standardization is not an over-night affair and will involve no scrapping of good equipment. France has been on a metric basis of measurement almost as long as the memory of man runneth, but I am told that even yet in the remote rural districts the old non-metric units are largely used in local trading.

The inch, pound and metric units involve us in trouble when considering international standards. The obvious way to get around it is by printing two columns parallel to each other; customers in metric countries can use the one in which they can think best. The metric system, or lack of it, is no bar to international standards, though it is an admitted difficulty, which benefits the printing trade more than anyone else.

Since the war, progress towards international rolled steel standards is to be noted on the part of Australia, Belgium, and France, as well as between ourselves and Britain. Plain angles present few difficulties; the channels, bulbs, and I-sections are the crux of the matter. Standardization of what we may term secondary ship materials such as brass, bronze, iron and wood is also to be kept in mind.

Again a real question is: How willing are the different parties to go at the matter and find a solution that will give the best sections designable and commercially manufacturable at this date? Without this willingness, we are merely beating the air.

The war has done at least one good thing: it has taught us that undertakings before considered impossible can be put through provided the will to accomplish is there; that men and women of many races can forget petty differences and work together for a common goal. Whether broad-gauge sentiments similar to those inspired by the stress of war can also be invoked for peace-time objects is at least open to debate, especially in the present condition of world affairs.

Again, do the foreign trade elements of each nation want uniformity in these matters, or do they want the Tower of Babel?

The transition stage would have its troubles; the present state has its disadvantages. The same solution for steel specifications, both as to composition and dimensions, as has already been applied to such matters as tonnage, safety regulations, etc., would appear to the writer as the proper one, namely, broad-gauge standardization on an international basis with equitable leeway to each nation as far as individual peculiarities are concerned, such as extend from mine to finished product.

In developing new countries, is it an advantage or a disadvantage to have similar struc-

tures and equipment built to varying specifications, and to whom do the advantages and disadvantages accrue respectively?

It is to be noted that the Department of Commerce, under Mr. Hoover's leadership, is endeavoring to eliminate waste and reduce costs and so to extend the benefits resulting from simplified practices in industry. The machinery that it is proposed to set up will be representative of all interests concerned and will have safeguards to prevent rejection of newer and better ideas as they come along.

Mr. Hoover uses the word "simplification," which is not the same as "standardization," though in many respects the two will be hard to separate. It is well to bear in mind the differences between the two words; their meanings and applications will converge and diverge as we study our subject in all its ramifications.

The procedure suggested by Mr. Hoover is very much that of the American Society for Testing Materials, where producers and consumers sit down together and agree to agree or agree to disagree on standard specifications for the major materials and their subdivisions.

A study of Mr. leMaistre's paper referred to above will throw an interesting light on what is being done along the lines of standardization and simplification in British shipbuilding and other industries.

A study of the pocket books issued by the different steel manufacturers will impress one with the vast number of special shapes to which steel is rolled; that a gradual reduction in number of special shapes would benefit everyone concerned will hardly be disputed. As existing commercial equipment wears out this becomes at least possible.

STANDARDIZED METHODS.

Regarding standardized methods of production, shipyards are organizations subdivided into many departments or trades. They are not unaware of what is going on in the general industrial world in the way of advanced methods. There are at least two good reasons why the practices of factories, pure and simple, cannot be fully applied; one is the diversity of product as between ship and ship, and the other is diversity of parts entering in to any one ship.

What all efficient yards are doing, particularly since the present depression set in, is to so organize their methods as to adopt for each shop the best that can be worked in. We all have certain routine ways of doing things. In a poor plant the routine runs the plant for a certain or uncertain season; in a good plant the routine is modified and improved conservatively and constantly in such a way as to cut down work, save time and labor, eliminate duplication, and also secure harmony and effective intermeshing of departments.

Too much departmentalization will kill any shipyard. You all know the small-minded departmentalist who cares not what happens to the department on each side of him, just so long as his particular department makes a good showing.

Modern established yards have their own standard ways of handling work; from design to delivery, standard forms and methods are used. These should only be changed conservatively, and after the management is sure that they have all the cards on the table; a change made to suit one noisy departmentalist will almost surely bring trouble and can very easily change a profit into a loss on the completed ship. We also have standard specifications. For yards handling more or less one line of work, this is undoubtedly correct; for yards with a diversified product it is still correct, but cannot be made to work without greater labor in

adjustment to particular cases. These specifications should follow in arrangement the yard charge and plan numbering system, so that an index is unnecessary to one familiar with the system, thus saving more time for more people than will be realized. The index should be there for convenience of owners and others not acquainted with the system.

It seems hardly necessary to say that all forms and drawings should be uniform, also all calculations, material-orders and correspondence methods. The responsibilities and limitations of each department should be clearly defined and no point left in the air to fall hapless between two or more parties.

STANDARD DETAILS AND FITTINGS.

We now come to standard details. Each established yard now has its own standards and each owner has his own particular requirements. Each yard wants to use its own standards, which works for a cheaper ship.

The British have decided that there is no good reason why a lot of fittings and equipment cannot be nationally standardized and, having decided so, they are doing it. There is a host of fittings that lend themselves to this treatment, such as manholes, airports, doors, davits, boats, bitts, cleats, chocks, sanitary fittings, winches, windlasses, anchors, chains, steering gears, etc., down to minor fittings such as cups and saucers. Providing the standards are of a good quality and agreed upon by the jointly interested parties, why not eliminate as much special work as we can? This British experiment is well worth noting as we press on our way to the building of ships economically.

With standardized fittings it is easy to see both time and money saved; stocks can be kept fuller without fear of loss.

STANDARD MACHINERY.

With reference to machinery, we have just arrived at standard specifications for moderate-powered, reciprocating-engined, Scotch-boilered cargo boats. We arrived there, however, in the midst of the modern upheaval in methods of propulsion; the claims of Diesel drives, Diesel-electric drives; electric, hydraulic or mechanical reduction-gear drives, direct-turbine drives, watertube boilers versus cylindrical, also last, but scarcely least, the war.

The standard specifications here referred to are those prepared in Britain with a view to harmonizing classification and governmental requirements for main engines and boilers and giving to builders one set of rules and specifications to work to. What success has attended their practical working is not known to the writer.

The reconciling of classification and governmental requirements where these overlap is something which will save time and money; the application of two or three formulae to figure out the same dimension involves duplication of effort and, consequently, waste.

Motors for ship propulsion are a modern development. We already find elaborate standardization here for several reasons; with uniform power per cylinder, engines of four, six or eight cylinders are built. Oil engines are complex affairs at the best; the more parts to a given design the lower the already high cost per unit of power can be kept. Further, their manufacture commenced at a period when the benefits of standardization were already realized.

Electricity plays an increasingly important part in the auxiliary installations aboard

ships. This industry is already highly standardized. The requirements of land and sea services should be brought as nearly to a common basis as is practicable.

REPAIRS AND UPKEEP.

The importance of quick turn around in ports needs no emphasis before this body. The advantage of standardization in giving owners and repair plants a reasonably generous stock of spares to draw upon is obvious. With greater standardization in building, especially in machinery, we automatically get advantages in the matter of prompt availability of parts for repairs and renewals, the economy of which speaks for itself. The more general the standards, the fewer and less expensive the spare parts each individual ship will need on board. Certain parts liable to be needed at sea will always have to be carried, but stocks at terminals can be kept lower without danger of delay to the ship.

Standardization is a natural and inevitable corollary of modern industrialism; mechanisms are both more elaborate and more generally used than formerly. A plant in Chicago manufacturing and selling any one or more of many well-known modern mechanisms must consider the ability of its distant customer to keep the machine in condition. What ultimate good is a typewriter, for example, which the owner cannot keep in repair; the "throw it away and buy a new one" answer is that of the reckless cub salesman, except after the machine is worn out or genuinely obsolete. The only proper answer is standardization of machine and of such spares as are most liable to be needed, backed up by the most efficient distributing agencies available.

UNIFORM REQUIREMENTS.

The codification of governmental requirements for merchant vessels under one set of regulations should be aimed at; at present these are scattered and come under different departments for enforcement.

The reconciliation of the requirements of two or more bodies with concurrent jurisdiction is very important. The most outstanding case in perhaps that of boilers, the U. S. Steamboat Inspection Service and the Classification Societies each having their own formulae. The success which has attended the adoption of the A. S. M. E. Boiler Code for land work needs no emphasis.

That the practical benefits of uniform requirements on an international basis are not lost to sight is evidenced by the recent reports of the committees appointed by the International Shipping Conference last November. These reports mark a step towards agreement on four important questions connected with shipbuilding, namely, life-saving appliances, wireless telegraphy, load line, and passenger ship subdivision. The absence of United States representatives on these committees is to be noted, the writer feels, with regret.

Uniform standards of strength for ocean-going vessels may well be considered; the proposed international load-line regulations give us a basis. The various classification societies each have their own; in practice they are fairly close to uniformity. The extent to which their rules could with advantage be standardized might well form a subject for future discussion.

SUMMARY.

History has shown conclusively that standardization has already greatly benefited mankind; imagine the chaos if each mechanic cut screw threads to suit his own ideas, as was done in the early days. The whole point is that of arriving at well-balanced decisions on how far to go. Excessive standardization makes for lack of progress, while too little tends to restrict production. The right amount means the maximum of comfort and pleasure in life for the minimum cost, *i. e.*, the greatest good for the greatest number. The Ford car, Singer sewing machine and Remington typewriter are good examples.

The same general principles can be applied to shipbuilding, particularly in countries where the volume of business is so proportioned to the number of plants that each can specialize along certain definite lines. There are different designs of cars, sewing machines and typewriters, each made by the same plant but for different purposes, so that even where standardization is most developed we do not find absolute uniformity.

DISCUSSION.

Vice-President Sadler in the chair.

THE CHAIRMAN:—Gentlemen, you have heard this paper No. 11, entitled "Standardization as Affecting the Shipbuilding Industry in the United States," which has been presented by Mr. Rigg, a Member of the Council. Mr. Rigg has made some very excellent points, and there may be some who want to discuss the paper.

PROFESSOR WILLIAM HOVGAARD, *Member:*—This is an important subject, and the paper is a very valuable contribution to it. Standardization, of course, can be driven to excess as stated by Mr. Rigg, but I think there is a way out of that by making the system of standardization sufficiently elastic, and in this connection I want to draw your attention to what they are doing in Germany in this direction at present. Unfortunately I am not in a position to give you full details on this matter; in fact I have most of my knowledge of it from a German magazine, *Werft, Reederei, Hafen (Shipyards, Shipping, Ports)*. In almost every issue of that magazine there is a list of standard parts of machinery and equipment of merchant vessels, ranging from big pieces of machinery down to coat hooks, comprising all fittings that go into a ship. These lists are issued by an organization called "Handelsschiff-Normen-Ausschuss (H. N. A.), (Committee of Standards for Merchant Vessels), which appears to be a branch of a nation-wide organization embracing, as I understand it, the entire German industry. It appears that these standards are elastic, being capable of modification as necessary.

The advantage of such standardization in the home market is obvious, but perhaps it is of still more importance in the foreign trade. Once a nation with a well-standardized industry gets a foothold in the market of a foreign country, it will be very difficult for any competitor to dislodge it. I think the industries of this country should take note of and study carefully what is being done in Germany in this direction; perhaps it would be worth while to adopt a similar system here.

Mr. Henry G. Smith, *Member:*—I think the Society is very much indebted to Mr. Rigg for keeping this very important subject before it. It is a subject which permeates all branches of industry, and the real difficulty behind standardization is human nature itself—the fact that no two persons think exactly alike.

Of course you have to balance the question of standardization against the question of progress. To my mind there is very little danger of standardization being a real bar to progress as progress will keep ahead of standardization.

So far as standardization pertains to the shipbuilding industry it covers two very broad subjects:

1. The standardization of ships themselves.
2. The standardization of parts of the ships and of the processes of building.

So far as the matter of standardization of ships themselves is concerned, I think we are very much handicapped in this country.

The real fundamental that governs the possibility of standardization is, of course, quantity production, and in this country it has never been possible in the past, except during the experience of the war, to have enough ships of the same type to standardize them to the extent they have done abroad. We must remember that practically every shipyard in this country builds a great variety of ships, ranging in several cases from tugboats to battle cruisers, and that there has never been enough building to make it possible for any one yard to specialize on a particular type of ship as is frequently done, however, abroad.

We will not overcome this particular handicap until we have enough ships to build, so that we can have at least a few duplicate ships. It is, of course, possible to standardize certain features of the design, but even here the practice varies with the different shipyards. Some advance, however, can be made in this direction, but it requires the cooperation of the shipowner to make it possible to adhere to the standard practice of the particular shipyard where his ships are built.

When it comes to the standardization of ship fittings, I had some experience on that line twenty years ago, when I was in the Navy. We started out to standardize everything in the way of fittings and thought we would be able to succeed on watertight doors, hatches, air ports, and also many other things, and we worked out the details with a great deal of care and submitted them to various shipyards and to a number of inspectors for comment, until we finally got in shape what we considered were A-1 standards, and used them as such.

The object of standardization is both economical production and quantity production, and unless you attain one or the other there is little value in the standardization of ship fittings. The difficulty we were up against was this, that no sooner was the standard issued then someone came along with the very urgent suggestion for an improvement, and, in spite of the most vigorous effort to maintain the standard when once issued, changes were made which destroyed the real value of standardization, as any change made in the design carried through in the manufacture. The jigs, fixtures, etc., that had been prepared for the economical manufacture of these standards had to be changed or were of no further use.

Many of you will remember the Long Arm System Company at Cleveland, Ohio. It set up to manufacture ship fittings and spent many thousands of dollars in the preparation of jigs for the manufacture of air ports, watertight doors, hatches, and many other appliances. The shipbuilding firm with which I was associated after leaving the Navy, bought many items from the Long Arm system (many fittings), and they were good fittings. We

bought at lower cost than we could have made them. This concern spent much money on the preparation of jigs and fixtures. The standards had not been in existence long before they were changed, and when they were changed the jigs and fixtures were no longer of any value; they had to be discarded. There had not been sufficient quantity production in the case of the various standards adopted to absorb the jig and fixture charge, and the result was they either had to go out of business or they had to make a new set of jigs and fixtures, and with not enough orders in sight to absorb the cost of the work, they were compelled to do the former.

So far as speed of production is concerned, standardization of fittings is of great importance. So far as cost is concerned, an important thing we should adhere to in standardization is that, having once had a standard, and it is doing good work, the standard should be adhered to until the cost of preparation of plans and machinery necessary to build the standard has been absorbed in the quantity produced. In this way the cost of preparation—that is, plans, jigs and fixtures—will bear but a small proportion to the cost of the manufactured article, and it is here that standardization becomes of real value because, through such quantity production and with the cost of preparation absorbed, the cost of the manufactured article becomes relatively small. This is the condition in the manufacture of automobiles. They standardize and stick to the standards for a year or more. To be sure, they may change the next year, but the preparation cost of plans, patterns, jigs, fixtures, etc., has been but a small part of the total cost of production of the many duplicate units and is not seriously reflected in the cost of the finished article. Under such conditions and after such costs have been absorbed, it is quite proper to modify the standard if there is enough quantity production in sight to permit of absorption of preparation cost in the new article. I would not say we should never change a standard, but standards, once adopted, should be changed only when there is some real advantage to be gained that is not found in the standard as used.

I hope that others will keep this subject before the Society, because it is one, in the present day of economy, and the necessity of economy, which, if judiciously handled, will result eventually in cheaper costs.

Rear Admiral Albert P. Niblack, U. S. Navy, *Vice-President:*—I think this is a most valuable paper. I want to say just a few words about the theoretical side of this question. In my earlier days I took this question up as being a very important one, but it has its dangers, and I am moved, therefore, to make a few comments. The author states in this paper that the absence of the United States representatives on the committee is to be noted with regret.

The Government, of course, has had its experiences, somewhat different from the average shipbuilding company, because on a larger scale and with military reasons. In the shipbuilding industry you have to consider various elements, as the previous speaker has most ably contended (and I have listened to what he said with the greatest interest). The point of view from which he considers the problem is naturally the commercial one, which should be that of shipbuilders and naval architects.

As a side remark, not particularly pertinent to the question, I have often been struck, in my forty-six years of service in the Navy, by finding ship fittings and other standard articles abroad which I assumed were of foreign manufacture but which I found were made in America, as we are more given to standardization than we really think. Once in Buenos

Aires, Argentina, I had occasion to order some office furniture, and I got it from a British firm which represented 360 different American firms. We sold the goods f. o. b., New York, and they did the middleman's business. The British have done a great deal of standardization in commercial shipbuilding, but I think we have probably standardized more in our Navy than has the British Navy. You all know, in our new standard design of destroyers, each one costs over $1,000,000. The design is well ahead of its time and has not yet been duplicated abroad in respect to horse-power, speed, torpedo equipment and up-to-date equipment generally, including mine laying and depth-charge dropping. We have built over 300 of these destroyers, the intention being to standardize everything possible on board, but as we gave them 28,000 horse-power for a speed of 35 knots we ran up against the impossibility of standardizing the engine and boiler fittings as each shipbuilding firm has special rights in engine and boiler construction. We, therefore, allowed wide latitude in the type of engines and boilers as long as the speed and horse-power were forthcoming. In other words, below the spar deck, in the engine and fire rooms, very little is standardized. Last year they had at the Charleston Navy Yard, of which I am now commandant, a great many of these destroyers on which it was necessary to make changes in the installation of the up-to-date fire control and, while the boats are absolutely identical in other respects, the hatches in the engine room and fire room to the spar deck are materially different because of the difference in design of the machinery installation. This was not a serious matter but only shows some of the difficulties of absolute standardization.

The Navy has carried out standardization of shipfittings, boats, boat davits, bitts, anchors, chains, and articles of supply in general, but there is a point beyond which standardization should not go. The previous speaker ably discussed this paper from a financial standpoint, which is the real one. We all feel that standardization is, on the one hand, an economic question and, on the other, it limits improvement in design. I have been a member of this Society for thirty years, and I feel that the Navy Department has followed standardization as far as it is practicable. It is a theory to which we would all at least like to approximate.

Outside of the question of design, we have had some able papers at this meeting on operating vessels, and I wish to call attention to the service of the Navy in standardizing certain features of operating. The Engineering Experiments Station at Annapolis has done excellent service in this respect in standardizing supplies used in operating, such as engine packing, oils, lubricants, construction materials, chemicals, brasses, and various other things which have saved thousands of dollars to the Navy Department.

It is very difficult to be entirely consistent in the question of standardization, and even if the Navy does it as a military question, it is not necessarily a guide to commercial practice. The crux of the whole question is that when standardization limits improvement in design too seriously it is not a good thing. The only thing of any real importance that I have to say on the question is that there are many standard fittings already on the market which are cheap and which will answer every purpose, so that naval architects and marine engineers, in designing, would save a great deal of money if they used catalogs of firms manufacturing standard articles which answer all purposes instead of entirely new designs, expensive and difficult to build. Shipyards, in repairing vessels, lose a lot of money in manufacturing articles which can be purchased in the open market through the free use of descriptive catalogs. There are an amazing number of standard articles manufactured in America as well as abroad, and great economies can be effected in utilizing them, because ships go abroad and

our own standard things are not always for sale in every port in the world. Mr. Henry Ford has given us a wonderful example in standardization which foreigners look upon with as much amazement as we do.

Mr. H. H. Schulze, *Member:*—We have heard many remarks regarding the value of standardization, and in one of these the previous speaker stole my thunder when he referred to the value of standardization in estimating.

Shipbuilding will exist only so long as the shipyards can make money, and it has been my experience that the contracts upon which we are most liable to lose money are those in which the specifications contain clause "as directed or approved by the naval architect." This was particularly true of the early naval vessels, and I remember, when Mr. Smith came to the Bureau at Washington, all ships were constructed under the "as approved" clause. The same argument applies to merchant work, and when we have the various items standardized the shipbuilder will know what he has to figure on.

The value of standardization as applied to shipbuilding can only be fully appreciated by those who have taken an active part in the development and who have made use of the results. No one could help but be enthusiastic when he stops to consider what standardization really is.

Before real standardization can be effected a thorough study must be made of all methods and practices relating to the subject, after which a standard is determined. In other words, the standard represents the best practice and knowledge of the art as far as is known to the one preparing the standard. It is intended to represent the best result for the least expenditure, and why, then, should not standardization be considered the proper procedure?

Standardization in shipbuilding only becomes effective when the shipowner is willing to accept the standards adopted by the shipbuilder. In many cases, however, shipowners, particularly large operators, have their own standards which render the standards of the shipbuilder useless and consequently entail an additional cost of construction.

When, however, the owners' requirements are not specific, standardization either of individual items, groups of items or methods of construction are of the greatest value not only in reducing the cost of construction but obtaining for the owner the best experience of the shipbuilder to meet the specific requirements.

It is, therefore, apparent that standardization will only become a fact when the owners have sufficient faith in the builder to accept his adopted standards as the best practice.

I thoroughly agree with Mr. Rigg's statement on page 208 of his paper that the ship as a whole can only be standardized under the conditions stated by him, but I also thoroughly believe in the standardization of items, groups of items, and methods of construction, which can be so combined as to meet practically the requirements of the owner.

Nearly all old-time shipbuilding companies have adopted standardization of items such as flanges, fittings, shackles, etc., but few of them have attempted the standardization of the entire system such as anchor gear, boat gear, rigging, etc. Where the standardization of such entire groups have been made it is of very great assistance in the preparation of bids, for the reason that, without investigation on the part of the estimator, he has immediately at hand the results, including weight and cost of the best practice, to fulfill the required condition.

It is surprising to learn how far such standardization can be effected when one really

makes up his mind to adopt this method. Even steam engineering piping, complicated as it is, can be standardized to meet practically all conditions.

One big additional advantage in standardizing ship construction is that it reduces largely the personal element and guesswork in estimating. A greater confidence can be had in an estimate which is a compilation of standardized units, and when bids are submitted on this basis they are comparable and uniform in their results.

Mr. Attiole J. Murray, *Member:*—While appreciating fully the able manner in which Mr. Rigg and subsequent speakers have pointed out the difficulties attending attempts at standardization of vessels, I am still not inclined to think that the idea of even standardization is one to be definitely shelved by any firm of shipbuilders in this country.

In England such firms as the Northumberland Shipbuilding Company and Russels of Port Glasgow have been largely built up on the production of "stock ships." Taking into consideration that the genius of this country leans toward standardization in general, this idea should prove capable of great development—it might even spell the difference in regard to the general freighter between building and not building.

Carried to its logical conclusion, standardization would resemble that existing in the automobile industry. There would be Ford ships and Dodge ships, and the buyer would take his choice and not be consulted individually as to their design.

After all, is there such a great difference in the required duties of the general freighter? Would not the owners forget their pet likes and dislikes—and very often they amount only to that—if the supposed standard ship was cheap and able to run on its merits as undoubtedly the Ford car is now doing?

There have been, during the last twenty-five years, very few developments in the hulls of vessels compared with other commercial products, and one need hardly be afraid when putting in a standardization plant of being overtaken and rushed off one's feet by successive radical changes.

Neither should the results of the hurried and blindfold attempts to reach this ideal during the war be considered an argument against standardization.

Possibly the matter will not be solved by conference but by the individual enterprise of some one having great vision, a small tendency to madness, and large tendency to spending money.

Mr. Carl E. Petersen, *Member* (Communicated):—This year's paper by Mr. Rigg is particularly appropriate, coming, as it does, at a time when the shipbuilding and ship-operating industries are at a low ebb, but hopeful of the changing tide. These industries, being of international scope and highly competitive, at present unaided financially by our government, especially need the benefits which accrue from reasonable standardization.

While much can be gained by standardizing the design and construction of vessels during the stress of war, it will be found generally that the standardization of the size and proportion of vessels does not readily lend itself for the reason that they are determined by the trade and economic conditions which are constantly changing. It would seem, therefore, that the greatest practicable field for standardization and simplification would be in the component parts: materials, machinery, details, fittings, equipment, etc., and methods used in the construction of vessels rather than in the vessels proper.

The present period of depression is an opportune time in which to make a concerted

effort to bring together the principals concerned, and endeavor to establish shipbuilding standards; in a moderate way first, followed later on a larger scale. The factors making for successful effort in this direction would include: (*a*) full representation, (*b*) an agreement of the principals to abide by the findings, and (*c*) provision for modification of the standards when necessary in order to insure progressive standardization.

This paper, which has been so ably prepared by Mr. Rigg, should serve to spur the industries to a realization that standardization is one means of enabling us to meet our competitors on the seas, and I think the author and the Society as a whole should be congratulated on its presentation.

Mr. Hugo P. Frear, *Member of Council:*—Mr. Rigg has presented us with a very carefully prepared and opportune paper on standardization as affecting the shipbuilding industry, setting forth many of the advantages that would result and difficulties that would be encountered if this could be accomplished.

There may be a difference of opinion or understanding in regard to the standardization of ships. I would not consider that a ship or its equipment was standardized unless the same vessel with practically the same equipment could be purchased from any one of a number of builders.

I do not think that the mere repetition of orders from the same plans, especially if for the same owner, constitutes a standard vessel. If, however, the builder could sell this ship without change to several owners and continue to do so, it would more nearly approach a standard ship, but not in the broad sense. Classification societies have had standard rules for many years. The stronger societies, until more recently, were very conservative and discouraged innovations. This resulted in a number of types of vessels built at different yards which were so similar by force of circumstances that they could be considered standardized substantially on the above basis.

The North of England tramp steamer offers perhaps one of the best examples of these types and probably approaches more nearly to the ideal than many of us will live to see again. They were contracted for almost exclusively on a deadweight basis, which bore almost a constant relation to both the displacement and gross tonnage.

Dissatisfaction on the part of both owners and builders to being tied down to hard and fast rules or governmental regulations, together with the advancement of the art and requirements of special trades, etc., forced these bodies to revise their rules on a more liberal basis. This all points to real progress but spells greater difficulty if not the impossibility of standardization of a ship as a whole. I am a great believer in standardization and do not want to create an impression that I would limit the work at a point beyond which it is possible to go. I do not think we can extend standardization much beyond fittings.

As Mr. Rigg points out, standardization has not been entirely neglected in this country so far as fittings and equipment are concerned. All of the principal shipbuilders have a very complete set of standards covering practically all the fittings commonly used on ships. Many of the larger shipowners also have standards of their own for many fittings. There are also some shipbuilders and many manufacturers making so-called standard equipment.

The trouble is that we have too many standards and too much personal opinion, and the problem seems to be principally one of simplification rather than standardization. Even this would involve a great amount of work and take time. I am on half a dozen or more standardization committees and know something of the labor and time that have been expended

on the standardization of very elementary details as compared with ship fittings. The important thing is to make a start and not undertake too much at one time. The first step would naturally be to map out a program covering the scope of work and the appointment of main and sub-committees.

Most shops have patterns, dies and jigs for their own fittings, much of which would have to be scrapped. On the other hand, of what use are these patterns, dies and jigs when you are building a ship for an owner who insists on using his own standards or wants to make changes in yours. Again, many fittings are adapted for cheap machining on a production basis to suit shop equipment. The tool maker, shopman and others have to be consulted before the adoption of a standard.

After simplification or standardization, what assurance have we that all the shipbuilders and all the owners would accept them? Would anything short of compulsion accomplish it?

Mr. Norman C. Wiley, *Member* (Communicated):—Referring to Mr. Rigg's remarks on standardization in Great Britain, it should be made clear that the work there has only been under the encouragement and supervision of the British Board of Trade and the British Engineering Standards Association. The actual committee work is being done by members of the Northeast Coast Institution of Shipbuilders and of the Institution of Engineers and Shipbuilders in Scotland. The same situation exists in this country, the American Engineering Standards Committee not preparing new standards in any field but merely accepting and approving such as have been prepared by technical and trade associations, and by keeping in touch with similar work abroad. In the conference on standardization in shipwork to be held here tomorrow, the Division of Simplified Practice of the Department of Commerce will extend its cooperation and advice, gained from similar campaigns in other industries, but will not propose to undertake the detailed technical work. The Society of Mechanical Engineers, of Heating and Ventilating Engineers, and others have committees of members at work all the time on standardization of selected subjects. In the marine field some organization must do similar work.

Coming particularly within the scope of this Society's endeavors would be the standardization of definitions of ship elements and of determination of the functions of ship form, also, of stability, trial, launching, strength and model-basin data. The latter has frequently been the subject of discussion here, but no action as to a standard method of presentation of results has been obtained. Published data, both in the volumes of the Society and in the technical press, are almost useless unless the same basic lengths, breadths and methods are used in obtaining the data. It would be advantageous if this Society had representation on committees of other societies standardizing products used by shipbuilders, or the privilege of reviewing and commenting on committee reports of allied societies before their final adoption by the A. E. S. C. as standards. Many such articles are now being simplified by the industries manufacturing the same, and this work should be closely followed.

Referring again to the British work on standardization, the results to date are rather limited, but their scope appears too all inclusive for imitation in this country. The eight panels into which the committee on hull fittings is divided are covering all manner of fittings in detail. The task must be enormous. As a start, and in view of the limited prospects of shipbuilding in this country, it would seem more profitable at first to confine efforts to such articles as are used in quantity on most ships and the size of which is independent of the size of the ship, as rail stanchions, floor drains and batten cleats. Simplification, or reduc-

tion in variety of sizes of a given article, should be striven for as a first aim. On page 207, Mr. Rigg appears to exempt the Navy Department from the adoption of merchant standards. For naval auxiliaries and vessels of other government departments, many merchant standards, if we ever have any such, could be used. Standardization should have for its first object reduced cost, which is obtained through quantity production. To obtain the necessary quantity, in addition to simplification of sizes, the greatest possible number of ships, including ocean, river and lake craft, private and government owned, should adopt the same standards, wherever such adoption does not lower utility or increase cost.

MR. RIGG:—Professor Hovgaard brings out valuable information on what is being done in Germany; they have appreciated the value of standardization for many years and there is little doubt but that they are further along in that field than is generally realized. Mr. Smith emphasizes the necessity of an ample market for the product after incurring the expense of installing facilities to accomplish standardization; he also cautions against too rapid and unwarranted changes in standards.

Admiral Niblack calls attention to what has been accomplished in the way of standard office furniture. Standard desks, files, book-cases, etc., are so familiar that we are apt to lose sight of their value; imagine a large office in these days without standard files. The Navy has for many years had its own standards and has thus materially assisted in demonstrating the advantages or otherwise of the general idea. It has gone further than building standards and is developing operating standards where such action can be taken advantageously. His reference to buying regularly manufactured articles instead of making special items calls attention to a point that can be watched more closely with advantage. Shipyards all do this, but some more so than others.

Mr. Schulze refers to the difficulty of correctly estimating on work that is not to recognized standards; his point is well taken. He brings out another good point when he refers to the shipowner's part in making standardization effective, and yet another in his reference to standard practice as regards groups, such as anchor and boat handling gear.

Mr. Murray in his reference to "stock ships" gets quite close to the large numbers of 7,000 to 8,000-ton tramps mentioned in the paper. In his reference to "Ford ships" I presume he is only speaking of "tramps," for liners could not be sold without very extensive consultation with owners and adaptation to particular trades involved.

Mr. Petersen gets to the root of the matter in the way he proposes to arrive at standards—full representation, abide by the findings and change when progress makes it desirable to do so. Mr. Frear cautions against too great expectations; he points out that some progress has been made and indicates the lines for future development.

Mr. Wiley points out the lines along which actual work can be accomplished and suggests specific lines for this Society; he calls attention to standard definitions of ship elements, particularly is this desirable in the speed and power field. This has been mentioned several times before this Society. He also makes a good point when he pleads for a merging of navy and merchant standards wherever possible.

This Society is represented on a number of committees having to do with standardization; among them, steel shapes, electrical installation on shipboard, pipe flanges and fittings, bolt, nut and rivet proportions, color schemes for identification of piping, also safety codes on electrical power control, for the forging industry and for plate and sheet metal working, etc., etc.

In conclusion, I wish to thank the gentlemen who have contributed so much of value in the discussion; any value that the paper may possess is greatly enhanced by this very full discussion.

I also wish to again thank you all for the more than kind reception you have accorded to the paper.

THE CHAIRMAN:—I am sure that I voice the feeling of this meeting when I offer Mr. Rigg the thanks of the Society for presenting this matter before us.

We will now turn to our last paper, No. 12, "Selection of the Best Kind of Propelling Machinery," by Mr. James L. Ackerson, Member. In the absence of Mr. Ackerson, this paper will be read by Mr. John E. P. Grant.

Mr. Grant presented the paper.

SELECTION OF THE BEST KIND OF PROPELLING MACHINERY.

By J. L. Ackerson, Esq., Member.

[Read at the thirtieth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 8 and 9, 1922.]

Never before has the marine engineering fraternity had so many different types of propelling machinery to select from, and there is no empirical formula which can be applied to help select the best type. The problem of the shipowner in this respect is the most important one he has today. Amongst the many factors to be considered in deciding what is the most suitable type are reliability (this is the most important single factor, for without reliability other advantages are very much discounted); economy in operation, initial cost, and weight, the relative importance of the last three depending on the type of ship under consideration.

Numerous papers have been presented at these meetings, practically all of them having been prepared by the shipbuilder—and they are thoroughly prepared, too; but there must be many factors that the shipowner is more familiar with than the shipbuilder, and it would be very interesting to hear from the shipowner his ideas on this matter.

RELIABILITY.

Reliability is something less tangible than the other three and responsibility less easily placed, because the factors controlling reliability emanate from two different sources: (1) the owner through the selecting of competent personnel; and (2) the builder. No matter how well a machine has been designed and constructed, if placed in the hands of an incompetent operator it will become unreliable; and *vice versa,* no matter how good the operating engineer, if the proper factors have not been used in the design and care in the construction, then the machinery is again unreliable; so that it is absolutely necessary for the operator to thoroughly understand and be whole-heartedly in support of any new design, and for the designer to realize that the cost of fuel per horse-power, while important, is not the only consideration. In the past five years we have had a very costly experience through sending to sea a large number of units (the design of which to begin with is questionable) in charge of engineers who were only half trained.

ECONOMY.

Economy in operation (that is, the fuel per horse-power) and initial cost usually bear a very close relation to each other, and it is only a question of figures to determine whether any particular type is worth the money as compared with any other type; and here again the type of vessel and the trade the vessel is employed in play an all-important part, as, for example, most tramp steamers over a cycle of, say seven years, are laid up for considerable periods at a time owing to there being no freight. During this lay-up the portion of expense due to fixed charges is going on all the time, while that portion consisting of fuel and supplies and operating personnel stops when the ship is laid up.

WEIGHT.

Weight is the least important except in the case of special types like shallow-draught boats, express-type steamers, warships, etc., because except in special trades—viz., coal, ore or oil-carrying—it is seldom that a ship is loaded down to a loaded draught mark, even when full of cargo.

With this brief introduction I will now present comparisons of the following different types of machinery and ships:

Geared turbines with Scotch boilers.
Geared turbines with watertube boilers.
Reciprocating steam engines with Scotch boilers.
Reciprocating steam engines with watertube boilers.
Diesel engine 4-cycle.
Diesel engine 2-cycle.
For 5,000-ton freighter at 10½ knots.
For 7,500-ton freighter at 11 knots.
For 8,800-ton freighter at 10½ knots.
For 10,000-ton freighter at 12½ knots.
For 10,500-ton tanker at 10½ knots.
For 17,000-ton displacement passenger ship at 15 knots.

From Plate 63 the one outstanding feature is the greater savings for Diesel-engine ships in the long-voyage trades, and this is chiefly due to the saving of cargo space required for carrying fuel oil rather than to the saving in cost of fuel oil, operating personnel, and fixed charges. Also, that for short voyages the Diesel engine should be given very careful consideration before a selection of the type to be used is made.

The different comparisons show that there is not much difference between the weight of Diesel engines and steam reciprocating engines, but it should be borne in mind that for steamers up to 12 knots speed the revolutions per minute of the Diesel engine are considerably higher than those of the corresponding steam engines—in the ratio of about 110 to 75. This undoubtedly means a less efficient propeller for all single-crew types. On faster boats the advantages of the slower revolutions per minute gradually disappear. In comparing weights, allowance should be made for reserve feed water for the steamer; if this is done, steam-engine weights will invariably be greater than Diesel-engine weights for voyages of ten days and over, except in the case of larger power geared-turbine jobs than those now under consideration.

It should also be noted that, whereas powers of four to five thousand are possible on single-screw steam installations, it is necessary to go to twin-screw installations for Diesel engines. This incurs an extra cost in hull construction, necessitating two shaft alleys which cut up the after holds and make it more difficult to stow cargo, as well as actually decreasing the cubic of the holds.

Originally it was my intention to resolve the saving in cargo space due to fuel-oil requirements into dollars per year, but owing to the uncertainty of freight rates I gave up the idea as being impracticable and have shown this advantage in tons per voyage. The alternative to carrying this large quantity of fuel oil would be to buy it at the ports of call. Which choice would be the better would depend, of course, on the price of the fuel oil at, and the freight rate to, those particular ports.

The initial cost listed in Plate 63 may be open to criticism, owing to prices being so spotty and varied at the present time. These prices are based on firm quotations of the lowest reputable bidder and include machinery installed ready for use. The same remark applies to weight. Different builders vary considerably, but, whatever error there is, the percentage of error will be the same for all types and will be in the same direction; and as it is the difference in cost and the difference in weight which we are most interested in, the percentage of error will be very small.

The machinery weights do not include hull engineering or any portion of the machinery usually located in the engine room but necessary for deck machinery only, such as auxiliary generating sets for generating electricity to be used on electric deck machinery.

I have not given the cubic required for the machinery space, because in all cases the space required is so near the 13 per cent required by the U. S. Tonnage Rules as not to justify the loss of the 33 per cent deduction to gross tonnage, which is permitted when machinery space is at least 13 per cent of the cubic of the ship.

I have not dealt with the engines which offer the greatest saving in space and weight, because up to the present time none have been built in this country, but it would appear to me that the opposed piston type of engines like the Fullagar and the Doxford offer many advantages that cannot be overlooked by the prospective shipowner.

From reports available, the Yngaren, fitted with a 3,000-horse-power opposed piston-type engine, made by the Doxford Company, has given an excellent account of herself for her maiden voyage from the British Isles to Australia and back. This engine offers one or two very desirable features, viz., a slow-running engine for comparatively large powers, with the consequent efficient propeller, considerably smaller engine-room space and one shaft alley only.

Owing to the Diesel engine builders standardizing around an engine of 2,500 shaft horse-power, I have used this power upon ships of 7,500 to 8,800 tons and on a 10,500-ton tanker. This assumption makes machinery for these types cost and weigh about the same but give us slightly different speeds. (The above figures hold good only so far as new machinery is concerned.)

It so happens, however, that at the present time there is hanging over the market a very large tonnage owned by the Emergency Fleet Corporation and available at very much lower prices than the present actual costs for replacing the same.

To convert any one of these 7,500 to 12,000-ton steamers into Diesel engine-driven boats, with 2,500 shaft horse-power Diesel engines, maintaining the existing auxiliary steam-driven machinery and deck machinery, would cost approximately $400,000, and this same change, together with changing the auxiliaries and deck machinery to the electric drive, would cost in the neighborhood of $550,000.

The first proposal would save the shipowner approximately 18 tons of oil a day; the second would save him about 22 tons of oil a day. For 200 days a year at sea and 165 days in port at $10 a ton for oil, the total saving for steam auxiliaries and Diesel propelling engines in oil would be about $36,000, and the extra for fixed charges would be $60,000. For Diesel propelling engines and electric deck machinery the initial cost would be in the neighborhood of $550,000. Saving in fuel oil would be 22 tons for 200 days and 5 tons for 165 days at $10 a ton—$53,000—and the extra due to fixed charges would be $83,000. The extra cost of lubricating oil for the Diesel engine will be offset by the decrease in cost of operating per-

sonnel, so that, assuming the same price, whether the owner will run the ship as a motor ship or as a steamship, the conversion is not justifiable except for the long voyages; but if these ships can be bought for conversion purposes at $30 a ton less than would be paid to continue as steamships, the fixed charges are reduced on a 10,000-ton ship to $37,000, and for almost any trade this change would be justifiable.

For conversion purposes under the Shipping Board plan, where new Diesel machinery must be had, it would appear that the larger boats offer the best possibilities.

Before closing I should like to say that, while I have taken 200 days at sea and 165 days in port per year for all the types except the tanker, this figure must, of course, depend on the trade the vessel is employed in. There are some trades where a ship is in port almost half the time, and it must be remembered that while a ship is in port it is not earning anything while the fixed charges are still going on. Therefore the more costly propelling machinery is at a disadvantage as compared to a cheaper type running only a small portion of the time.

While I consider the table (Plate 63) a good guide, the only way the best type can be selected is by a careful comparison of the different types in the particular trade an owner wishes to engage in along the lines given in the table, taking into account the character of the freight, length of voyage, freight rates, cost of fuel oil at ports of call, etc.

DISCUSSION.

THE CHAIRMAN:—This paper, No. 12, entitled "The Selection of the Best Kind of Propelling Machinery," by Mr. James L. Ackerson, Member, is now open for discussion.

MR. JAMES C. SHAW, *Member:*—Mr. Ackerson is to be commended on his interesting paper, although it is open to controversy. It is regretted that he has failed to give us more basic data from which he draws his general conclusions. It would have been more illuminating, for instance, had he given more particulars in regard to the hulls for the size of ships he has under consideration. It would also have been of particular interest had he carried out his figures for the net earning capacity, both on deadweight and bulk cargo carried for the particular lengths of routes chosen. He refers to the unfavorable higher revolutions of the motor ship compared with the steamer as affecting propeller efficiency, which he states is in the ratio of 110 to 75. This proportion of revolutions, however, only holds good for a twin-screw motor ship and a single-screw steamer, and not for a single-screw motor ship and steamer, as is to be implied.

It should be pointed out, in this connection, that Messrs. Burmeister & Wain eight years ago ran trials on a twin-screw motor ship and a single-screw steamer for determining this point now raised by Mr. Ackerson. This was the motor ship Suecia, having a length between perpendiculars of 362 feet, a beam of 51 feet 3 inches, and a draught of 23 feet 1½ inches, corresponding to a displacement of 9,625 tons. The steamer was the Prinsessan Ingeborg, with a length of 360 feet, a beam of 48 feet 9 inches, and a draught of 21 feet 10 inches, corresponding to 8,660 tons displacement.. The engines in the Suecia were of the earlier design of Diesel engines in which the high-pressure stage of the injection air

compressor only was connected to the main engine, thus giving a mechanical efficiency of 80 per cent against the steam engine of approximately 90 per cent. At 11 knots, taken from the standardization curves, the Diesel indicated horse-power is 2,130 and the steam 2,050. Correcting the power of the motor ship to that of the steamer, in proportion to the two-thirds power of the displacements, the Diesel indicated horse-power of the twin-screw vessel actually becomes less by 50 horse-power than that of the steamer, although the former is handicapped by the lower mechanical efficiency.

Burmeister & Wain have recently developed a line of special long-stroke four-cycle single-acting Diesel engines for single-screw vessels of the smaller type and which engines are designed to run at the same revolutions as the single-screw steamers. It might be mentioned also that the Cramp Company is building one of these engines for installing in the Hog Island "A" ship Seekonk, in which the speed of revolutions will be kept the same as for the original steamer.

Mr. Ackerson also particularly refers to the single-screw motor ship Yngaren, having an engine of the opposed piston type, for bearing out his original statement. With two cylinders added to the Seekonk, the indicated horse-power becomes 3,000, or the same as that of the Yngaren, with the weights of the engines practically identical. From published data, I found that the single-screw vessel above referred to requires from 5 to 10 per cent more indicated horse-power than a Burmeister & Wain twin-screw installation, and actually consumes 15 per cent more fuel based on the indicated horse-power as developed.

Mr. Ackerson refers to the advantage of the one-shaft alley versus the two-shaft alley, but this only holds good for the smaller size vessels. In the larger vessels the increased cargo capacity, by having only one alley, is proportionately smaller and more than outweighed by other advantages peculiar to the twin screws, as, for instance, the greater propulsive efficiency, better maneuvering qualities, and less length of engine room required. It has been found that the difference in the propulsive efficiencies of the single-screw and the twin-screw ships is more favorable for the latter with the increasing size of vessel.

Criticism is to be made of the powering of the vessels as shown on Plate 63. This is particularly so of the 7,800-ton, 8,800-ton, and 10,000-ton deadweight vessels which have the same power of 2,500 shaft horse-power, and designed for 11, 10½, and 11 knots, respectively. For the smaller vessel, which is apparently the Hog Island Type "A" vessel, 100 more shaft horse-power is to be employed than for a standard type of motor ship of 9,500 tons deadweight built in large numbers abroad, with a sea speed of 11 to 11¼ knots. For the 8,800-ton vessel, Mr. Ackerson apparently has in mind the type built at his yard which, at 11 knots, requires approximately 20 per cent more effective horse-power over some other vessels of the same deadweight but of about 10 feet more length between perpendiculars.

It should be mentioned here that, in drawing comparisons between steamers and motor ships, this is too frequently done by using steam machinery of very light and cheap construction, which barely passes the Inspection Rules. These vessels accordingly only operate at about 70 per cent of the rated capacity in actual service. Motor-ship machinery, on the other hand, must be made of the highest class of workmanship and material and will always deliver its rated power, being in no way influenced by conditions outside of the control of the engineer personnel.

It would have been more instructive, showing a much more favorable condition for the motor ship, had Mr. Ackerson made his comparisons on the basis of equal net cargo-carrying capacities for the particular types of machinery. As a rule, it would have been

found, taking into consideration the smaller all-round year horse-power required for the motor ship, due to the better immersion of screws under all conditions of draught and more uniform running conditions, that the motor ship would be appreciably smaller than the equivalent steamer, resulting in a smaller investment of capital and a higher earning rate on same. (See Plate 64.)

Mr. W. W. Smith, *Member:*—On page 226 the author states that weight is the least important of the economic factors. From my study of the subject, I conclude that weight is, next to fuel consumption, the most important factor. Since the cost per pound for this class of machinery does not vary greatly, the first cost is largely a function of the weight. In addition, the deadweight and the cargo-earning capacity are reduced in proportion to the weight of machinery for deadweight vessels.

With reference to loading, the class of cargo determines whether it is a cubic or deadweight vessel. Certainly there are many vessels which are loaded to the draught marks, including tankers, colliers, ore carriers, general cargo vessels handling weighty cargo, etc. It would seem, therefore, that the author's statement in this respect is not entirely correct.

Referring to the propulsive efficiency on page 226, the twin-screw vessel will probably be slightly more efficient, but the difference will probably be not more than 3 or 4 per cent. Referring to the problems in Mr. Stevens' paper where the speed is about 11.5 knots, we have for single-screw vessels propulsive efficiencies based on shaft horse-power as follows: (1) .62; (3) .645; (4) .595. The only twin-screw vessel of this speed is problem 13, where the efficiency is .54, which, however, is probably low. These values do not show that single-screw vessels are particularly inefficient.

In comparing the propulsive efficiencies of single- and twin-screw vessels, it should be remembered that, while the single-screw loses considerably due to a high effective slip ratio, it, on the other hand, gains greatly due to the higher hull efficiency.

With reference to revolutions, increasing the revolutions for given conditions of speed and power will reduce the propulsive efficiency. This effect is well illustrated by the ρ—δ diagrams in Admiral Taylor's book. Thus the tendency to high revolutions for Diesel engines results in reducing the propulsive efficiency.

Referring to the advantages pointed out on page 227 for double-acting engines, we have made a number of comparisons which agree with this. In addition to the larger powers possible, these engines are much lighter and should therefore cost less.

Referring to Plate 63 the data given are too general in character, and there are not sufficient particulars to make a really accurate comparison; a description of the machinery installations is desirable. The types and makes of engines, turbines, gears, etc., will have an important bearing.

In addition to the general type of machinery, the design and conditions are important. There may be wide variations in weight, cost and efficiency due to these causes. For example, the fuel oil consumption of a geared turbine vessel may vary from .85 to 1.3, depending on these factors of which we are not informed. The weight and cost may vary likewise. The revolutions will influence the weight and efficiency considerably.

In making a comparison of this kind, the best designs and conditions should be selected. Apparently this has not been done for the 2,500 shaft horse-power geared turbines. At any rate, the results given are inferior to those which we have obtained with certain designs of Parsons turbines.

Referring to the column headed weight, it would be interesting to know whether this is the weight wet or dry, and whether any reserve feed water has been included.

The weight of the geared-turbine machinery with Scotch boilers for the 2,500 shaft horse-power installation is given as 570 tons, or 510 pounds per shaft horse-power which is assumed to be the wet weight. This seems too high since we have built a number of 2,600 shaft horse-power installations which weighed 480 tons or 413 pounds per shaft horse-power.

We have also built a number of 3,100 shaft horse-power installations which weighed 560 tons or 404 pounds per shaft horse-power.

The weight of the 7,200 shaft horse-power installation of geared turbines and water-tube boilers is given as 1,140 tons or 354 tons per shaft horse-power. If I am informed correctly, the weight of the machinery installation on the President Pierce, which was described by Mr. Warriner, is 1,040 tons or 180 pounds per shaft horse-power using the trial power. This is considerably less than given in the table.

The fuel consumption of the 2,500 shaft horse-power geared turbine vessel is given as 34 tons per day or 1.27 pounds per shaft horse-power. This is surely a very poor performance. In view of this, it would be of value to have particulars of the turbine design, steam conditions, etc. For Parsons turbines, of good design, we would estimate a fuel consumption of 1.08 pounds per shaft horse-power, or 29 tons per day. The steam conditions are: 200 pounds 50 degrees sup. and 28¼ inches vacuum.

For the 7,200 shaft horse-power installation the table gives a very much lower fuel consumption than above or 1 pound per shaft horse-power for a 3,600 shaft horse-power unit. Values so far apart do not seem very consistent.

The fuel consumption of the two-cycle installations are exactly the same as for the four cycle. It is my understanding that, for usual designs, the two cycle will use about 7 per cent more fuel than the four cycle.

It is noted in group No. 4 that 3,400 shaft horse-power twin-screw Diesel vessels are compared with 4,200 shaft horse-power single-screw steam vessels. With such a wide difference of power I cannot see how such a comparison can be of practical value.

The price of fuel oil for the steam vessels is taken at $10 per ton, whereas the Diesel oil price is $11.50, $11.60 and $11.80. The price differential is therefore 15 to 18 per cent greater for the Diesel oil, which is rather low.

Referring to the length of voyage between fueling ports, the table gives distances up to 20,000 miles. For most of the trade routes used by American vessels, a leg of over 6,000 miles is not ordinary. Hydrographic Chart No. 1262 illustrates this very clearly.

Referring to the saving of 22 tons per day given on page 227, this would apply to an inefficient steam installation, but for an efficient Parsons turbine I would expect a difference of about 17¾ tons.

For the 2,500 shaft horse-power installations, the fuel consumptions of the steam engine and turbine are both given as 34 tons. For the 7,200 shaft horse-power installation the steam engine consumption is given as 94 tons, whereas the turbine is given as 77 tons. This appears inconsistent.

The differential of $30 per deadweight ton referred to on page 228, would amount to $300,000 for a 10,000-ton vessel. No doubt, with such a differential, it will prove profitable to install Diesel engines in these hulls.

Referring to the last paragraph and to Plate 63, this data may be of value in considering the particular designs upon which this table was based, but I think it would be misleading

in several respects to use it generally. Some of the data do not represent the best practice. Also, the conclusions which may be drawn from such a table may be in error.

Furthermore, a comparison of the engine-room machinery only neglects certain factors which have an important bearing. Consequently, to obtain a true comparison, it is necessary to compare values for the complete vessel.

I agree with the author that the only safe way to determine the best type of machinery is to prepare an estimate of net earnings for the particular designs and routes concerned.

The truth is that, at present, the economic advantage of the Diesel engine over the best type of turbine installation in most cases is not great, and rather close figuring is required to decide the best type. In such a close comparison, a change in economic conditions may reverse the decision.

There are many cases where the best designs of Diesel machinery have advantages. Furthermore, the field of the oil engine is increasing. However, its commercial value would be greatly increased by reducing the weight and first cost.

Mr. John L. Bogert, *Member:*—After what has been said in this discussion and thanking Mr. Ackerson for bringing up the subject, I will not take up much of your time. I will show you some things by Mr. Ackerson's own figures. If you turn to Plate 63, you will see that he states there that the steamer of 7,800 tons deadweight capacity consumes for twenty-four hours 34 tons of oil, and that the Diesel ship is put down as using 11 tons.

This morning we heard interestingly from Mr. Mallory, shipowner and operator, that he could not run a ship on oil down to South America because he could not get oil down there, and he had to buy coal at Durban and very poor coal at that. Mr. Ackerson has not given the Diesel engine due credit for what it can do on short runs. In a run to Norway the captain of a Scandinavian boat, which had an engine of about this size, reported that he sold enough oil out of his double bottom in Norway to pay every last cent of cost of fuel for his ship. That means something. There is $83,000 put down here, every last cent of which belongs to the credit of the motor ship on that run, and the same way in the case of Mr. Mallory.

We may talk about the Hog Island ships. I will not go into anything bigger, because they are a drug on our hands—we have so many of them, and some of the speakers on standardization put a quietus on ships of this size for many years to come.

Many of these ships will be changed to Diesel-engine ships, and I will not discuss whether they will be a long-stroke engine—with the Diesel engine they will have to have at least 54-inch stroke to have 720 feet piston speed, at 80 revolutions, to be first class, or whether someone will make them into twin screw. The other answer would be an electric motor on the shaft and Diesel engines in the engine room developing the juice.

There are two or three good solutions for these methods, but the point I want to bring out is this—that on the way to Scandinavia and back it is perfectly possible for a ship that can load 1,000 tons of oil in her double bottom to actually travel for nothing, so far as fuel goes, and you heard here this morning that it takes as high as 30 per cent for fuel to operate a ship.

You only have 1,000 tons capacity in the bottom of the boats to take care of surplus fresh water for your water-tube boilers, and you must have 15 per cent standby in case of emergencies, which means it would be 1,173 tons for a thirty-day round trip per steamer.

Let us take the author's own figures, 11 tons for the Diesel-engine ship. I want to tell you that the Selandia and the Jutlandia have not burned over 9 tons per day. I am giving you the benefit of the doubt and charging the motor ship up with 11 tons. Eleven tons per day for thirty days means 330 tons, and adding 15 per cent, which is 49.50, amounts to 379.50 tons. If you subtract 379.50 from 1,173, you will get 793.5 tons in the double bottom which could be saved out of that ship to pay her expenses. Thus, taking the figure of $10 a ton cost for oil means you will have approximately $5 a ton on that transportation. In that case, $3,967.50 for what you sold, and the cost at $10 a ton for what you burn—you will remember that the cost is $3,795—you would be ahead almost $200, besides paying for all the oil you burn on the round trip, there and back.

Professor Charles E. Lucke, *Member* (Communicated):—The author is correct in saying that the answer to the question of whether Diesel or steam machinery will be better for any given vessel, and the answer that refers to any one type of either kind, is a matter that must be worked out by evaluating a large number of variables. While, of course, certain general conclusions can be arrived at, the final solution must rest on detailed figures. It is true, as the author says, that if the voyage is long enough, or the sea days per year great enough, the motor ship will pay over the steam, but the question then arises as to how much is "enough." The real question, therefore, in this problem is one of *method* of treating these many variables so as to give clearly the answer sought.

After many attempts to do this in tabular fashion, supplemented in some cases with curves, all were rejected finally in favor of a new mode of procedure, which seems to be satisfactory and has been used by many people since its publication. This method of treatment, which leads to the desired solution in a very clear fashion, was expounded in a paper presented by me before the Franklin Institute, Wednesday, April 20, 1921. This paper was printed in the Journal of the Institute, July-August, 1921, and is entitled "Internal Combustion Engines in Marine Service."

It is very likely from the text of the paper here under discussion that the author was not familiar with this method, and his attention is invited to it as a means of making more clear the relations between the variables that he discusses and as a means for reaching the final answer.

It is pointed out in conclusion that numerical values for any one variable, such as number of men in engine-room crew, price of fuel, freight rate, cost of engines, all of which vary from time to time, may be treated in the method that is demonstrated as real variable and not as fixed quantities. When tabular methods are used exclusively, these figures, when given a proper range for any one item, lead to so many answers that the tables obscure the issue. This is wholly eliminated by the curve method.

Mr. Ackerson (Communicated):—Mr. Bogert is quite correct in that some of the inner bottom capacity could be used for cargo space in the shorter voyages and is a point that should be thoroughly considered when deciding the question of type of machinery.

The author is not familiar with Prof. Charles E. Lucke's paper entitled "Internal Combustion Engines in Marine Service," but it would appear from the short description given by Professor Lucke that his method of treating the subject is an excellent one.

Mr. Smith in his criticism says that, on account of the cost being largely a function of weight, weight is second in importance to fuel consumption. In my paper I mentioned cost

and weight as two different factors, and if the two are treated independently then I do not think Mr. Smith is taking issue with this statement.

Referring to Mr. Smith's comments on the data listed on Plate 63, it was not the author's intention to go into great detail of the various installations, as this would require too much time and space. I have taken fair average examples of ships now in operation.

The fuel consumption on the 2,500-horse-power turbine units is very liberal and might be improved upon, but I do not think it would be a fair comparison to take the best figure that a steamer could do and compare that with a Diesel engine, because invariably the Diesel engine will come nearer her fuel guarantee than the steamer.

The author has not found that geared-turbine units of 2,500 horse-power and less are any more efficient than steam reciprocating engines; it is only in units of greater horse-power that the turbine begins to be much more efficient.

The weights given are net, no reserve water is included, but the allowance for reserve feed per day is given in another column.

I note Mr. Smith considers the weights too high. In this respect I would call attention to Mr. Shaw's remarks. Mr. Shaw thinks these weights are light. There seems to be an honest difference of opinion, but nothing has been presented to cause any change of opinion on my part.

The fuel consumption of the 2,500 horse-power is very liberal; the designed steam conditions were 200 pounds dry steam, 28 inches vacuum. While the 34 tons might be improved upon, this is what actually is being done. If the consumption is reduced to 29 tons per day, this will not change the author's conclusions.

I would expect a much lower steam consumption per horse-power on a 7,200-horse-power unit than I would on a 2,500-horse-power unit, and I don't think the values given in the paper are far wrong.

Referring to group four, a comparison can be made by taking the speed given for each type and figuring the time required between each port.

The prices for fuel oil are actual quotations to an operating company. Referring to length of voyage, while 6,000 miles is fair, still 9,000 miles is not unusual in the far eastern trade, and if an operator does not want to pay a higher price for fuel in the East, it means taking enough on board for 18,000 miles.

In reply to Mr. Shaw, I explained in the paper my reasons for not giving the extra earnings of the motor ship due to increased cargo space in dollars and cents instead of in tons. It is, however, a very simple matter to select the trade and then substitute dollars for tons.

Referring to the comparison between the revolutions of the motor ship and steam ship, the author had in mind a single-screw steam ship and twin-screw motor ship, because in all the cases under consideration, with the exception of the passenger vessel, it would be possible to power the ships on a single screw with steam, and the point I wish to make was that in many cases it would be possible to power a steamship on a single screw when it would be necessary to use twin screws on a motor ship, and the advantages of a single-screw ship over a twin-screw ship are such that steam should be given this credit.

With reference to the comparison between the single-screw steamer Prinsessan Ingeborg and the single-screw motor ship Suecia, Mr. Shaw's figures are not convincing, because there is nothing to show that both hulls are equally efficient, and a comparison of the two, correcting for the displacement only, is not sufficient; the ships have different block coefficients, that of the steamer being larger. This would indicate that the steamship is a more difficult ship to propel.

The fact that Burmeister & Wain have developed a long, four-stroke, single-acting Diesel engine is very significant and is a step in the right direction. The claim for one shaft alley against two holds good for the larger vessels as well as the smaller. The advantages are, briefly, cargo space saved and initial cost less. These are not offset by propulsion efficiency, less engine-room length, better maneuvering qualities.

There is nothing in the figures presented by Mr. Shaw to show that the twin screw has a better propulsive coefficient.

Better maneuvering qualities by a twin screw over that which a single-screw vessel has do not bring in any more revenue.

Engine-room length very seldom exceeds that required by the 13 per cent law for the type of vessel under discussion.

The powering of the vessel is not the question, as indicated by Mr. Shaw's discussion, for if the power is too great in some cases and too little in others, this will not affect the conclusions to be drawn, because the same power has been used in both steam and Diesel.

Contrary to the statement made by Mr. Shaw that the steam weights are those for a "light and cheap construction which barely passes inspection rules," the weights are based on the conservative practice of one of the best and oldest northeast coast firms. Mr. W. W. Smith in his criticism states that the steam machinery weights quoted in my paper are on the heavy side.

Referring to the last statement in Mr. Shaw's discussion, wherein he points out that a much more favorable condition for the motor ship would have been attained had comparisons been made upon another basis than that used in the paper, the author wishes to emphasize the fact that it was not his aim to make conditions favorable to any particular method of propulsion, but to state as clearly as possible the fundamental facts now available in such a manner that the steamship owner or operator might draw his own conclusions.

As indicated by the various members who took part in the discussion of the paper, a much more comprehensive study of this subject could be made than that which was made in its preparation. While issue has been taken on a number of points, the author is gratified at the interest displayed by the discussion which followed the reading of the paper. The author realized at the time the writing of the paper was undertaken that the subject was one of timely interest, and for which no formula could be given which would be a panacea to cover all the conditions existing in the various trades, the solution of which can only be found by the operators after giving due consideration to all factors affecting their particular trade.

If this paper and the discussions which followed its reading have served to indicate the scope of the subject, and at least some of the factors to be considered in the determining of the best type of propelling machinery for a particular trade, then the paper has attained all the results hoped for by the author.

In conclusion, the author wishes to thank those members who entered into discussion of his paper for the kindly and helpful interest displayed.

THE CHAIRMAN:—I think, gentlemen, that closes our meeting for this year. I much regret that our president was called away, but I think you will agree with me we have had a very successful meeting. The meeting now stands adjourned.

The meeting adjourned amid loud applause.

APPENDIX

December 26, 1922.

Mr. Walter M. McFarland, President,
The Society of Naval Architects & Marine Engineers,
29 West 39th Street, New York.

Dear Sir:

I beg to submit the following report on the presentation of the greetings to our sister society in Japan on the occasion of the twenty-fifth anniversary, occurring this autumn.

I cannot speak too highly of the keen insight on the part of our officers that prompted this procedure because, in my judgment, it has more than fulfilled their most sanguine hopes. It has turned out to be a means of cementing the friendly relationship not only between two very important bodies of active workers, but also between the nations themselves.

It was certainly a great honor that was conferred upon me in being permitted to be the bearer of these greetings, consisting of an engrossed sheepskin under the great seal of the Society. The occasion of their twenty-fifth anniversary proved to be unique.

It was found upon arrival in Japan that the Naval Architects and the Imperial Japanese Navy had very close relations, as none other than Vice-Admiral Baron M. Kondo, who is President of the Society, is in charge of the official model basin of the Navy, located in Tokyo. The naval authorities, as well as the Society itself, were full of appreciation of the thoughtfulness of the sister society in America in sending these greetings, and for no other purpose than to allow them to be presented by me personally, although I assured them this was unnecessary, the meeting was advanced so as to occur prior to the date of my departure from Japan.

The ceremonies were held in the auditorium, which constitutes a diminutive opera house included in the labyrinths of the new Imperial Hotel at Tokyo. The occasion was a very formal one, inasmuch as the various departments of the government were represented in full dress regalia, and each, as called upon, read a document of greetings and congratulations to the Society on the successful completion of its first quarter century.

The activities of the Society appeared to be of an extremely high order of importance and the group is one of the most active engineering bodies in Japan, consisting of very capable and high class naval architects, constructors, engineers and ship operators. All branches of shipbuilding and ship operation are apparently represented by their most active men.

In preparing for my little address I came upon a fact that was rather startling to me, which afterward received very full corroboration from the authorities at the Tokyo Imperial University as well as some of the old students of ships and shipping in the Navy Department; that is, that the Japanese were probably the first to go down to the sea in ships and become masters of this most noble and ancient of all the engineering arts. Records would seem to indicate that somewhere between 500 and 1,000 years prior to the activities of the Phoenicians, the Japanese were building seaworthy ships and were masters of the dual art of shipbuilding and navigation, because at this early date they were familiar with the adjacent coasts of the continent of Asia. And nothing is more logical than that this should be

true, inasmuch as practically the whole of Japan is covered with almost impossible mountains that from most ancient times have rendered inland transport so replete with hardships as to drive the people down to the sea in ships.

I had been in Japan some weeks before the occurrence of these impressive ceremonies and had become much impressed by the marvelous progress in all branches of engineering and shipbuilding that has been made by the profession and the Japanese people generally, and I did not hesitate to make known to my audience the extremely favorable impression they had made upon me. My address, taken down at the time, was as follows:

"Mr. President, Gentlemen of the Council, and the Society of Naval Architecture of Japan:

"It is a very great honor for me to be permitted to appear on this auspicious occasion of your twenty-fifth birthday and to bring you greetings from your neighbor to the east. We are a long way apart physically, but we have been drawn closer and closer as the years have passed, especially in the minds of thinking men.

"Broadly speaking, naval architecture is the highest example of engineering and the most ancient. What, then, is more fitting than that this ancient art of engineering should be the intermediary between the two nations? Shipbuilding is an art of the greatest importance as shipping and transport is one of the foundations of civilization. It was one of the earliest necessities felt by human beings, and as necessity always brings to us the object—we say 'necessity is the mother of invention'—so it is necessity that made the first ships that the Phoenicians went down and explored the Mediterranean with. They went to England to get tin and brought this then precious metal back to Asia Minor. They inspired the intrepid Viking to cross or at least to explore the Atlantic.

"But it seems to me that your people must have been among the first in the world to go down to the sea in ships, because having just come from the western part of your country, as far as Nagasaki, I was never out of sight of mountains, endless mountains. To me they are cruel and oppressive to poor Japan, and it may have been the mountains that drove you to the sea for easier transportation. It must have been your people who were the first to engage in this greatest engineering feat of making ships that would ride out the seas. History shows us that you knew all about Korea at a very early date. This shows that your early ships must have been seaworthy. The sea which I crossed to Korea was by no means a smooth sea (our ship rolled almost incessantly). So all honor to the Japanese people for their being one of the first, as I see it, to go down to the sea in ships.

"We are so young in America that our Society of Naval Architects there is not an old body, but a very active one, and they have led others of our great engineering bodies to join them and extend to you the heartiest greetings on this occasion of your half-jubilee period. We look upon the jubilee period as being fifty years. I remember being appointed one of the official delegates from America to attend the first jubilee meeting of the Institution of Naval Architects of Great Britain, so they are leaders of us all in the activities of a society of naval architects.

"But in America it is the shipping and ships, as expressed in our Navy and naval activities, that have been the means of joining our two nations closer together than ever. For what could we have done at the Washington Conference without the able backing of the Japanese people? They stood there day after day with their steady purpose, and it was only through their able support that those extraordinary measures were carried forward. It so happened that I knew something of the activities that brought the final result, and the

treaties, as they were finally drawn up and passed by our Congress and passed by your authorities, contained more that was heard of conference discussions emanating from your Commission than those of any other nation. That is a great honor to you in and of itself.

"Now America wishes to return, even though in a very slight measure, and has seized upon this great occasion. We have in our country a society or body formed of delegates, usually two, from the various engineering bodies, that is known as the Engineering Foundation. I have the honor of being a member of that body, and our president, Mr. Rand, only back from his vacation two or three days before I left, conferred with me on this matter and authorized me to represent the Engineering Foundation on this occasion as well as the meeting of your Society of Mechanical Engineers, who also had an anniversary. This Engineering Foundation, including its members at large, represents same 42,000 engineers and extends its heartiest congratulations to you on this auspicious occasion.

"Again, one other Society with some 14,000 members who consider themselves a little closer allied than possibly some other of our foundation societies, such as the Electrical Engineers with some 13,000 members and the Civil Engineers, for instance, comes forward.

"We started out in the ancient times with sailing ships. Our vessels were blown across the seas, but that time has passed and a ship—and especially a battleship—is the most highly organized piece of engineering in the world. The naval architect is a wonderful man who not only has to be a naval architect, but a mechanical engineer, electrical engineer, a first class metallurgist, and he must have knowledge in many other fields to accomplish his results. Considering the results he must achieve, his knowledge must comprehend all, but most falling within the comprehensive field of mechanical engineer. So the American Society of Mechanical Engineers have sent their greetings by me over their great seal, duly executed. If I am permitted, may I read the document.

"Then comes your own sister body in America, the American Society of Naval Architects and Marine Engineers. They have honored me by sending by my hand a somewhat more formal greeting which I shall briefly read to you. This is also under the great seal of the Society and is duly signed and executed (*Reads*)."

THE SOCIETY OF NAVAL ARCHITECTURE OF JAPAN

GREETING

THE AMERICAN SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

herewith extends its

Heartiest Greetings and Congratulations

on the

Successful Completion of your First Half-Jubilee Period

Transmitted by the hand of Elmer A. Sperry, E. D., Member.

Signed by the President and Secretary-Treasurer, this seventh day of September.

W. M. MACFARLAND,
President.

DANIEL H. COX,
Secretary-Treasurer.

I wish I could convey to you some idea of the bright and expressive faces that greeted me and the heartiness of the applause, that was nothing short of remarkable. A great many greetings were extended and statements made afterwards by individuals, and all were characterized by sincere and emphatic expressions of appreciation and the wish that the two societies might be drawn into closer association and go hand in hand in the prosecution of our common interests.

I do not think it is out of place to add here that from my observation we can learn much from the Japanese people in point of national spirit, which makes for solidarity and unity of action, and also patriotism in general.

It has certainly been a great honor for me to meet such an important body of earnest workers and find that they are extremely appreciative of any thought or act that comes from our great land. It is my suggestion that we henceforth seek ways and means for more complete cooperation and for frequent interchange of engineering and development experience. The Japanese people are coming on with leaps and bounds and their activities are becoming so important that there is no question but that we will receive great profit by such a procedure. They are doing more and more original research work in important lines. They have four model basins to our two in this country. Another matter that impressed me that might be of interest to our Society is that the shipbuilding yards of Japan seem to have more business than we do, averaging, so far as I was informed, about two years' work with their present force.

I am enclosing a more formal acknowledgment of the greetings from Vice-Admiral Baron M. Kondo, president of the Society, which I hope will be published in our annals.

Very truly yours,

ELMER A. SPERRY.

ACKNOWLEDGMENT OF GREETINGS.

15 YAMASHIROCHO, KYOBASHIKU TOKYO,
28th Oct., 1922.

MR. W. M. MACFARLAND, PRESIDENT,
American Society of Naval Architects and Marine Engineers.

DEAR SIR:

In the name of the members of the Society of Naval Architects, Japan, I have the honour of accepting the document of greeting from the members of your esteemed Society on the occasion of the half-jubilee celebration of the founding of our Society. It was formally presented at the meeting by Dr. Elmer A. Sperry and was received by everybody present with great enthusiasm.

Please present our sincere thanks and good wishes to the members of your Society.

Wishing your society the greatest prosperity, I remain,

Very faithfully yours,

M. KONDO,
President.

THIRTIETH ANNUAL BANQUET

OF

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

HELD AT THE

WALDORF-ASTORIA HOTEL, NEW YORK, N. Y.

THURSDAY EVENING, NOVEMBER 9, 1922

LETTER FROM THE PRESIDENT.

THE WHITE HOUSE
WASHINGTON

October 25, 1922.

My dear Mr. McFarland:

I regret exceedingly that it is not possible for me to be in attendance at the banquet of the Society of Naval Architects and Marine Engineers, which is to be held on the evening of November 9th, in connection with the program of observance of American Marine Week. With all my heart I wish I might be a participant on that occasion. No one purpose more enthusiastically enlists the attention of the present administration at Washington than that of turning our vast assets in ships into a live and efficient Merchant Marine. Every day adds to the conviction that the upbuilding of our Merchant Marine is of first importance in assuring our national defense and of incalculable importance in maintaining America's fitting place in the commerce of the world. It would be a pleasure to me to express some of my hopes and convictions to those who will be present at your annual banquet. Since I am unable to attend I will thank you to convey my very cordial greetings and to express the hope that American Marine Week and this notable meeting of your society will add to American conviction that we must establish and maintain this agency of transportation on the high seas if we are to maintain a position of becoming eminence in the world of trade.

Very truly yours,

Warren G. Harding

Mr. Walter M. McFarland,
29 West 39th St.,
New York City, N. Y.

REPORT OF SPEECHES AT THE THIRTIETH ANNUAL DINNER OF THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS HELD AT THE WALDORF-ASTORIA HOTEL, NEW YORK, N. Y., NOVEMBER 9, 1922.

The President of the Society, Mr. Walter M. MacFarland, acting as the Toastmaster, after the service of the coffee and cigars, called the company to order and said:

"Gentlemen, we shall take great pleasure in continuing this evening the practice which has existed in this Society for the past thirty years. I ask you all to rise and drink a toast to the President of the United States."

The company rose and drank the toast while the band played "America."

THE TOASTMASTER:—Gentlemen, the hour is late, one hour later than we had hoped to begin the exercises, and therefore you will hardly expect me to make any lengthy speech. There are other speakers who will address you this evening, and I am quite sure that you will be highly entertained by what they say. We had allowed ourselves a hope, at one time, that we might be favored with the presence of the President as our guest of honor this evening, and acting on that hope we sent him an invitation to be our guest. Owing to the illnesss of Mrs. Harding there was some delay in the reply, but finally the President wrote and said he was very sorry that he could not come, and he sent the foregoing letter to be read this evening.

Since President Harding could not come himself, he has sent a distinguished representative, whom we might consider an ambassador extraordinary, and in introducing this gentleman, whose name, of course, you see on the program, I may say that it is an unusual and a very great pleasure, for now we have a Secretary of the Navy who is a real sailor man, a man who has actually served at sea in the Navy. He is not in the position of one Secretary, more or less famous, in having found out that a monitor was actually hollow. Our Secretary knows all about ships. He served in two wars and made a distinguished record all around. He comes with a special message to us from the President, and it gives me the greatest pleasure to introduce to this company the Hon. Edwin Denby, Secretary of the Navy. (Applause.)

ADDRESS BY HON. EDWIN DENBY, SECRETARY OF THE NAVY.

Mr. Toastmaster and gentlemen, I recall the incident of the Secretary of the Navy who discovered that the damn thing was hollow. I do not know, however, whether he or any succeeding Secretary has discovered that the damn brain is hollow sometimes. (Applause.)

I deeply regret the absence of the President, who most earnestly desired to be here tonight. Only this morning, in asking me to convey to you verbally, as he has already done by letter, his respects and his earnest hope for the success of the establishment of an American merchant marine, he said he regretted exceedingly that he could not be here himself. I know he loves the merchant marine; as for myself I could not be in more congenial company than amongst men who love ships, make ships, and sail in ships, and endeavor to build up the merchant marine of the United States. It has always been my dream, and during a period of six years in Congress I voted, whenever I had an opportunity to vote, for a ship subsidy, and I do not care whether they camouflaged it under the term "subvention" or "government aid" or any other term. A subsidy is needed, and we might as well call it a subsidy. (Loud applause.)

I am not going over the history of the great Washington Conference, but I am going to ask you to bear with me for a moment while I refer to it.

The purpose of this conference was to limit the naval armament of the powers in such manner that their safety might be well provided for while at the same time a burden of taxation might be lifted from the shoulders of the peoples signing the treaty and the danger of war minimized. It was the most remarkable conference ever held by the powers of the world in that they agreed to a self-denying ordinance lessening their own power afloat. Nothing like it has ever been known before in the history of the world, and few conferences have been so splendidly successful. The far-seeing vision of the President and the stern and incisive eloquence of the Secretary of State, together with the great sacrifice the United States made and the receptive and agreeable attitude of the other powers anxious to find some solace for their tortured people, led to the acceptance of the American proposals. And I want to say to you gentlemen, many of whom are builders of ships and operators of ships, that no better example of the patriotism of the American people could have been asked for than their attitude in supporting the results of that conference.

Do not think for a moment that we in the Navy Department fail to appreciate what it meant to many of you. Through the ranking officers of the Navy, it collaborated with the American Commissioners in utmost harmony and with a cordial desire to bring to fruition this highly beneficial policy. I can pay no greater tribute to the personnel of the Navy than to say that I found in no instance the slightest desire or purpose to put above country the selfish interests of the individuals of the service, and I have yet to hear of any officer in the United States Navy who failed to cooperate cheerfully and willingly.

So we stand today as agreed at that conference that we are left to maintain, after the treaty shall have been signed, sealed, ratified and exchanged, eighteen battleships. The treaties have not yet been ratified and exchanged by all the powers, and therefore the Great Treaty for Limitation of Naval Armament is not yet the law of the land. It will be as soon as the exchanges occur, but in the meantime we look forward to that period when we shall

be compelled to limit our fleet to eighteen capital ships and an indeterminate number of smaller craft.

I want to speak rather briefly tonight, because you have here men whom you will hear from, who will present to you, in a much more forcible way than I can, the merchant marine problem.

But I want first to emphasize this fact, so often forgotten by the American people, that a fleet is not a fleet if it consists only of combatant ships. We would be absolutely helpless on the occasion of a great war unless we were in a position to draw upon an adequate merchant marine. It would be altogether too expensive to provide for the greater ships of the fleet, for the smaller ships of the fleet, and for the air vessels of the fleet, the necessary auxiliaries, and maintain them, year after year, in times of peace. We cannot think of that. The American people would not tolerate that for a moment.

We have had several examples in our history, pitiful examples, of what it means to attempt to operate away from the shores of the United States, without auxiliaries in sufficient number.

You will not have forgotten, of course, the war with Spain, and you will not have forgotten the efforts of our government in scraping all the ports of the world to get enough American bottoms, flying the American flag, to transport our little army of 25,000 men to Cuba, and you will not have forgotten, I am sure, that after our armada sailed, all informed Americans were, metaphorically speaking, on their knees in prayer that there should not come a heavy blow at sea, because they knew some of the vessels carrying these men could not weather a storm, and they would not reach the end of their cruise with their precious cargoes of American fighting men.

I was on the deck of one of these auxiliaries serving as a sailor, and in the long distance we saw the fleet pass that was carrying the men to Cuba, and we literally prayed that there might be no rough weather. We knew the condition of the fleet, and everyone else knew it, but the Lord God of battles was with us, and the ships steamed on their way and landed their cargoes safely. (Applause.)

Then the United States went on after that demonstration, indifferent to the fact that a merchant marine is a vital necessity, until another striking illustration was given of what it means to attempt to send a fleet to sea on a distant mission without auxiliaries.

When President Roosevelt, himself always a friend of the Navy and the merchant marine (applause), sent the twelve battleships around the world, he was compelled to use for auxiliaries, repair ships, supply ships, refrigerating ships, hospital ships, and all the others that constituted the train of the fleet, foreign ships under a foreign flag, and it was obvious that, had the United States then been at war, this vast fleet could not have sailed, or if it had, would have been stranded in some foreign port because it could not carry enough supplies of any kind to finish its long voyage.

I do not know whether or not the President had it in mind—but I have always thought he did—amongst other motives he may have had in sending the then greatest fleet that ever assembled under the American flag, around the world—I always thought he had the motive to demonstrate to our people the absolute and vital necessity of American ships under the American flag if we were ever to maintain our own in time of war. (Loud applause.)

After war is declared you cannot get ships of other flags. It is quite obvious that you cannot sail without them, so I have thought that President Roosevelt probably wanted to

make that clear to the American people, in order that they might awake some time to the need for a merchant marine.

I speak to you of the merchant marine in its purely defensive character, as part of the defensive armament of the United States, a vital and necessary part. In the Navy we know perfectly well the exact meaning of war without ships to draw upon for auxiliary service, and surely the late war demonstrated the need for the American flag to be well represented upon the high seas. We have allowed our merchant marine to decline, and we are now trying to build it up again.

A sight that saddened me was seeing, while on a recent trip abroad in Yokohama Harbor, the Robert Dollar flying the British flag—not that I do not have a great admiration and great respect for the flag of Great Britain, but I did not care to see it flying over a ship that had once flown the Stars and Stripes and which was named after the great shipowner of our own country.

I do not know whether you feel as I do about the psychology of our flag and the need for showing it all the world over—and now I am not speaking for the national defense, and I am back again to plain, common sense dollars. It seems to me that the merchant who continually is compelled to ship his goods abroad in foreign bottoms, under foreign flags, must be looked upon by the people who buy them as representing a strange country. We know here that we have the men, we have the money, we have the inventive genius, and everything that goes into the making of a ship, and we have foreign trade, but, believe me, the future of the United States demands we shall increase that foreign trade very greatly. The day will come when we will meet a competition heretofore undreamed of in all the markets of the world, and when that day comes it will be well, indeed, if we have ready to meet it not only the goods but the ships to carry the goods. I believe that the old illustration holds good: What merchant delivers his goods in the delivery wagon of his rival bearing the rival's advertisements on the wagon? What merchant would be so far behind the march of progress as to do a thing like that? And yet that is what the United States has been doing for many years.

I look back with delight upon the old days of white sail and clipper ships, when we built the best ships in the world. We met the world in competition then and we carried our share of the world's goods, and I cannot see any reason why, simply because the fabric has been changed and the method of propulsion has been changed, that America cannot equal any other nation on earth in the building and sailing of the vessels that ply the seas, and conquering of the markets too. (Applause.)

It is a curious thing. We are not accustomed to hide our light under a bushel; we are accustomed to go after things and get them, and yet for a generation we have fought for this thing, a proper subsidy, or something which will enable us to restore upon the seas the flag of our country. The mere stating of the fact that we are not represented in foreign trade as we should be, that we are not transporting goods in our own ships, seems to me all that is necessary.

I do not know, again, whether you will agree with me, but I have lived a number of years in foreign countries, in the days of long ago, when I was a youngster. I remember once, when walking around the bluff at Chefoo, suddenly coming around it and, looking into the harbor, I saw an American man-o'war flying the flag of the United States. It thrilled me, as I doubt not it would have thrilled every American who might have seen it, and whose hungry eyes had been denied the sight for many months, and I had no shame,

and you would have had no shame, if tears filled your eyes with joy when you saw your country's flag.

Think what it means when the vessels come in and the people in foreign countries look in vain for the starry banner. We must endeavor by every device to protect what we have of a merchant marine, to make all the necessary endeavors to see that it shall be replaced in operation, and to see that the size shall be increased so that there will be a fair showing of the American flag everywhere in the world.

You know it is only the Navy, or practically the Navy, that shows the flag, but there are many places in the world which the Navy does not reach. May I speak for a minute of the Navy? I just want to say this—you know about the Navy and what it is made for. Primarily it is made for peace, and in order that it shall accomplish its great peace mission it must be maintained at the fighting edge of efficiency, and it shall be so maintained, but it is made for peace and will accomplish peace only if it is kept up to that edge of efficiency. And if we are attacked, we shall not have sent out our fleets in vain, for they are efficient, and the men are properly trained, and so even now we ask annually of Congress only enough to keep up the fleet and maintain it in an efficient condition, but our American people sometimes forget that wars spring up without warning. I have heard it said, over and over again, it takes two to make war—but no, it takes only one to make war, and it takes two to make peace. (Applause.)

Our people for many years have too frequently acted as did the village council, which met every month, and at one of its meetings solemnly resolved that the volunteer fire apparatus should be put in a state of repair and well furbished twenty-four hours before each fire. That is the American idea, apparently. It cannot be allowed to continue, and if we are to keep up our defensive armament to its proper strength we must accompany it with vessels that carry the cargoes of the United States, that build up its trade, and strengthen its arm and make it known, and finally, when need be, can take a part in the defensive armament itself.

If the people of the United States only knew what the Navy means in time of peace! They do not dream that it is the best insurance that can be given to any country in the world, and they do not think for a moment that, even if the treasury was becoming bankrupt in any ordinary business, the last thing which would be allowed to go would be the insurance on the business; and yet, apparently, the American people have been willing in the past to let the insurance go and to permit the country to stand uninsured and subject to the hazard of attack at any time. True, they do not know that the Navy of the United States is worth infinitely more than it costs our people in time of peace, through its splendid humanitarian work.

Not long ago a man came to me who was at Smyrna during the burning of that city. He said he had not the language, and that no language contained words, to describe the horrors of the burning and slaughter, but he said that he wanted to tell me of the splendid action and conduct of the United States Navy. (Applause.) He described the little destroyers, the leopards of the sea, the splendid weapons for the defense of ships, and how they saved many lives from the waves of the sea, how they were converted into Angels of Mercy and took off as many men and women as they could. It is not only the saving of the thousands of men, women and children, but it means forever, for generations to come in that part of the world, and in every part of the world where the United States Navy has been able to do that sort of thing, that the flag of the country shall be held in reverence

and we shall have a friend. Think of our officers and men of the Navy of the United States, patrolling their lonely beat up and down the Yangtze River, sometimes protecting property, but always safeguarding the interests of American men and women. All the time, all the world over, the Navy is engaging in some work of humanitarian benefit to the world. And always, too, inspiring sound confidence in the United States, and that confidence will last us so long as we give good reason for it, principally in our policy of defending humanity. Sometimes it will be continued and strengthened by our actions when we may be required to defend ourselves, and if we keep and maintain our Navy and at the same time fail to build up our merchant marine, you know, as well as I, that half our strength is gone. There is no use for any complicated ships of war lying in the harbor, for you cannot send them out, because you have not the auxiliary equipment in the form of additional ships to enable you to send them out. (Loud applause.)

I spoke to the President this morning, as I told you, and he asked me to give you words of greeting, and say that Congress would be assembled in special session about the 20th of November, and he earnestly hoped that the Merchant Marine Bill would then be passed.

He asked me to read you a letter, another letter of greeting and of confidence, and of earnest hope that runs parallel with yours and with mine. The letter is as follows:

"My dear Secretary Denby:

"I learned through Colonel E. A. Simmons, president of the American Marine Association, that you are to address the banquet of the Society of Naval Architects and Marine Engineers, in New York, on November 9th.

"It was with much regret that I was obliged to decline an invitation to be present at that time; and I am now writing to ask you to express to the gathered meeting my hearty interest in the work of this organization and my conviction that it represents the most useful contribution to the development of the American maritime interests.

"I am sure that I do not have to add much to what I have said on other occasions concerning my profound interest in, and concern for, the future of the American merchant marine; its development and continued usefulness will not fail to constitute a large contribution towards the broadest material prosperity and the truest security of our country.

"It is always a satisfaction to acknowledge the debt which is owing to such voluntary organizations as the American Merchant Marine Association, for their efforts in behalf of this great cause.

"Most sincerely yours,
WARREN G. HARDING."

(Applause.)

THE TOASTMASTER:—The formation of the great Emergency Fleet during the war, and in that connection the organization of the Emergency Fleet Corporation, was a great accomplishment, but with the signing of the armistice and the ending of the war there was no further necessity for such a great number of ships. With the advent of the present administration there was a change in the organization of the Emergency Fleet Corporation.

Without wishing to criticise what has occurred in the past, I think we can all rejoice that apparently, under the present administration, the criterion for appointment is no longer that a man shall know nothing about the job which he is to fill, but that he shall know a great deal about it.

The next speaker is a representative of the new order of things, who was called in to help in the administration of this great merchant fleet. He is a man whose whole life has been spent in connection with shipping, so that when he came to take hold of the work it was not something he had to learn about, but something that he was very well acquainted with, and as a result his work is highly efficient.

It gives me great pleasure to introduce Hon. William J. Love, Vice-President of the Emergency Fleet Corporation. (Applause.)

ADDRESS BY HON. WILLIAM J. LOVE, VICE-PRESIDENT OF THE EMERGENCY FLEET CORPORATION.

Mr. Toastmaster, Honorable Secretary, and gentlemen, Mr. Stevenson Taylor's letter arrived in Washington at a time when we were all very busy. After I finished reading the first paragraph, which contained an invitation to this dinner, sent to me by the chairman, I was uncertain whether I could come. When I got back to my desk and was about to make up my mind I would accept it, I saw the second paragraph, which contained an invitation to speak. Then I made up my mind that the old saying was true, that those who dance must pay the piper, whether it was in making speeches at dinners, or any other thing. If you will bear with me, then, I will give you a little picture of the present conditions of American shipping, as viewed from a shipowner's standpoint.

It is not necessary for me to delve into the history of American shipping since the Revolution, as all of you no doubt are better posted than I am. Sufficient to say that we are aware of the many bright, if not brilliant, achievements associated with this period of our growth, and to conclude that, once having been successful, we can again succeed—not by talking or "waving the flag," but by commercial freedom and hard work in which we will need the assistance of "all hands and the cook."

The entrance of our country into the World War in April, 1917, found our shipping in a deplorable condition, at least with respect to world-wide general cargo trading, and my entire remarks are on this basis, that is, excluding services to contiguous countries, to the West Indies and Central America. A brief description will be helpful.

On the Pacific there were, I think, two American flag steamers trading to the Orient —the China and the famous Minnesota—and three to Australia via our South Sea Island possessions, the old established Pacific Mail Company service to the Orient having disappeared about a year previously.

There were perhaps eight or ten ships under our flag trading to Central America and the west coast of South America.

Off the Atlantic Coast we had the American Line to Southampton and one or two passenger ships to Antwerp. The Atlantic Transport Company was using the recently acquired ships of the Pacific Mail in its London trade.

The splendid fleet of the American Hawaiian Company was principally engaged in the intercoastal trade and to the Hawaiian Islands.

The fleet of the United States Steel Company was in its infancy, they having a few steamers trading with their products and general cargo in various directions.

This will give you a fair picture of the activities of American ships in world commerce prior to the war.

Untold difficulties were experienced in getting the first 20,000 troops to France. It was not long before it became evident that ships were needed more than any other thing to win the war, and it was with this object that our fleet was conceived and built. Later, of course, it became equally evident that it would be an important factor in commercial trading.

Subsequent to the armistice, the great fleet of some 1,500 steamers was divided among, roughly, 270 firms, many of them overnight creations, without experience, without the proper personnel, without foreign agencies to manage and parallel the established routes of maritime nations established for hundreds of years.

There was more cargo offering than there were ships to carry it. Rates were on a plane unheard of. Anyone could make money. No attention was paid to keeping the cost of operation down. No attention was paid to the huge claims resulting from inefficient management and operation, and in most cases no money was set aside for the future, with the result, in my opinion, that the tremendous operations for American ships for the two years following the war, from which we should have benefited beyond measure, were not only without value but actually detrimental to the upbuilding of our merchant marine. Only in adversity, in trial, does the true business sense become whetted.

I place the period when we started to gain any real experience about June, 1920. This was when rates commenced to take a tumble, and it was not long before everyone in the shipping business became aware of the value of the dollar owing to the keenness of the competition.

When Chairman Lasker assumed control of the Shipping Board's affairs in July, 1921, for the first time he was able to draw about him men who had had the bitter experience of going through the ups and downs of the shipping business for many years. The average "man in the street" does not appreciate what has been accomplished. I can say to you, however, in all sincerity and without fear of contradiction, that it has simply been marvelous. The country owes to Chairman Lasker the deepest debt of gratitude.

To give some idea of the activities of the Shipping Board, it will no doubt interest you to know that today we have regular established services to a very large extent sailing on appointed dates from 40 ports of Continental United States, and serving no less than 229 ports throughout the world. These services are performed by 83 established lines of steamers. Included in this number are five passenger, mail, and cargo service, namely: New York to London, New York to Bremen, New York to Brazils and River Platte, San Francisco to the Orient via Honolulu, Seattle to the Orient, and a sixth service, which will be inaugurated very shortly between the principal ports on our Pacific Coast and the Brazils and River Platte ports via Porto Rico.

The figures that you get from time to time of the proportions of our export and import trade carried in American bottoms are misleading in certain respects. If they could be dissected to show the advances that we have made in the general cargo trades, you would be surprised.

I cannot tell you what it has meant to bring these services up to their present point of efficiency. It has been possible only by the loyalty, determination, and cooperation of a small group of men. We have a long way to go yet, but the fact remains that we are at present well and favorably established.

A large number of incompetent and inefficient operators have been eliminated. Duplication of services to a large extent has been rectified. Agency arrangements and berthing facilities in foreign countries, while vastly improved, are not yet entirely satisfactory. Then, again, we have had the tremendous handicap of receiving, from underwriters, foreign and domestic ratings that immediately placed us at a disadvantage with our old-established foreign competitors. I am glad to say on this point, however, that conditions have greatly improved, but we are more or less in the unfortunate position of a strong and clever prize fighter—none of the leading lights in the profession will take him on for a championship contest until after he has gone out in the rough and tumble ring and made a name for himself. We have got to make a reputation. While statistics show that possibly about one-third of our insurance is placed in foreign admitted companies, this is not a true picture, because

much of our export business is done on a F. O. B. basis, or, in the case of imports, on a C. I. F. basis, which means that the consignee or shipper in foreign lands has the placing of the insurance, and naturally he places it in a foreign company who has no particular interest in promoting the success of the American merchant marine, or, in fact, any flag other than his own. This is cold business.

So much for what has been done by the Government. This, however, is not and should not be our goal, for governmental ownership and operation make for waste, destroy personal ambition and incentive, and with the vast fortune of this country back of the same cast a shadow over all commercial enterprises wherever we come in competition.

Let us now look at what has been done in the development of privately owned lines since 1917. On the west coast there are two passenger ships trading transpacific; two trading to Australia; and perhaps a dozen cargo steamers to the Orient, Central America and South America. On the Atlantic we have two excellent services to German ports, and one of the largest manufacturing concerns has increased its fleet to well over forty bottoms that cover many important trade routes. The intercoastal trade, which is a restricted one, is absorbing today between 600,000 and 700,000 tons of the best American ocean-going cargo ships. Of course this tonnage would be available in time of war for any service it might be called upon to fulfil.

This comparison, therefore, of our position in 1916 vs. 1922 is anything but a pleasant one, for it shows that, so far as privately owned shipping is concerned, we have made little or no progress in developing services to move our exports or imports in world-wide trading. If it is the country's wish that we have a merchant marine, then it can only be successful in private hands who will, by energy, ambition and resourcefulness, if proper laws are enacted, place it in a position to compete freely with the flags of other nations. While it is true that many maritime nations operate ships under restrictive laws, as a rule, owners are generally free to take advantage of every means at their disposal to reduce costs of operation to the lowest possible point, and this during periods of depression means simply "the survival of the fittest." Are we headed that way, or are we headed the other way? Countries whose laws are too harsh reflect this lack of commercial freedom in the size of their commercial fleet. While most of the government fleet which is available for off-shore trading is good enough for pioneering work during the development period, the ships generally are not good enough to give, when they eventually fall into private hands, real competition to those of other nations. Read the history of practically every old established service in the world. The ships they employ today, so far as their construction and type are concerned, are the result of years and years of experience; in other words, they were built to meet the special requirements of the trade in which they are engaged. Now, what are we doing along similar lines? As near as I can learn we are at a standstill. True, there is an order given every now and then for a West Indiaman, or an ore carrier, or a collier, or a special type of tanker, and while I am interested in this development it does not go far enough. It is only a fraction of what we should be doing. Our ships will be wearing out some day, and if we do not get ahead speedily along these lines we are going to find our shipyards with grass growing along the ways and rust forming in the machine shops. Don't think I am painting an all-blue picture; I am just stating facts.

We have reached a point where a decision must be made. The war has been over four years, and while world trading is, of course, in a most depressed condition, the wise and prudent man or country prepares in advance for peace or for war and does not wait until either is at his front door.

With our inexperience, with our higher costs of operation due to a number of causes, with our foreign agency and equipment arrangements none too good, with our insurance disability, with other maritime nations fighting to hold their trades, with a period of depression that will never right itself until Europe settles down, with the privilege of free interchange of commodities impeded because we cannot hope to sell to impoverished countries unless we buy from them and put them in funds, we must have some form of assistance for a restricted period during which these handicaps can be overcome or disappear and a free field established for our merchants and shipowners.

In the meantime I appeal for support of American flag ships on patriotic grounds only when they are able to furnish exporters, importers, and travelers with service as good as our competitors, and when they do not, write a red-hot letter to the owners or to the Shipping Board.

I do not believe that we will ever participate in world trading beyond that which flows to and from our shores and our insular possessions, and then only in liner or semi-liner services. I mean by this that the tramping business of the world will remain in foreign hands. The very nature of our economic conditions precludes its growth to or from our shores, whereas the very nature of the economic conditions of a number of foreign countries is exactly the reverse. We will never get our costs down to a point where we will be free competitors in other than direct trade to any great extent, therefore I think we should concentrate on the liner business, and if we can reach a point where we can handle, say, 50 per cent of our imports and exports, I think I can safely say from my experience during those trying years of the war that we will be practically an independent nation, with all the benefits accruing, including the famous "invisible" exports that come to us from freight earnings and which are never recorded in any statistics; freedom to direct our exports to countries where for one reason or another other nations are indisposed to help us; and, of greater importance, the training of a vast number of men who "go down to the sea in ships"—for a living.

Before closing this address I would like to say a few words in memory of H. A. Frye, my close associate and vice-president. If ever man laid down his life for a principle, it was Mr. Frye. He was warned before he came there that overwork would mean death, but in spite of all warnings he did his duty, and I think his name should be written in our record.

THE TOASTMASTER:—Gentlemen, it has been a custom of long standing with us to show our respect for the military forces of the Government by inviting the naval officer in command of the Third Naval District and the Brooklyn Navy Yard and also the general in command of the military division which includes New York. Almost without exception we have been honored by the presence of these gentlemen. We have with us tonight Rear Admiral Carl T. Vogelgesang, Commandant of the Third Naval District, and Brig. Gen. William F. Weigel, who comes as a representative of Major General Bullard in command of the military division.

Admiral Vogelgesang is a naval officer of distinguished record, having commanded a number of our great battleships and seen active service during the Great War. His duty for more than a year past has been as Commandant of the Third Naval District and the Brooklyn Navy Yard. A very distinguished honor has recently been conferred upon him in his selection as the Chief of a Special Naval Mission to our sister republic of Brazil, on which he departs early next month. It gives me great pleasure to introduce Rear Admiral Vogelgesang. (Applause.)

ADDRESS BY REAR ADMIRAL CARL T. VOGELGESANG, U. S. NAVY.

Mr. Toastmaster, Mr. Secretary and gentlemen, I have been asked to say something about the necessity for a real American merchant marine and to show why the Navy is concerned with the question.

We as a nation are once again drinking deeply from the well of hope, and in drinking we are forgetting the teachings of history.

We are discounting experience and paying a premium on dreams.

We are trusting that there will be no more wars, yet the world is seething in unrest and its economic life has never been so upset or so chaotic.

No human soul has yet been able to point out a path that will lead to normal stability.

Political and social unrest dominate the world, and in the midst of this turmoil we have repeated over and over again that there will be no more wars—a confusion of thought between hope and reality.

We do not desire war. God knows we abhor it. But we have no right to throw a smoke screen around the realities of history and inculcate in the minds of our people a false sense of security which leads to spiritual and material unpreparedness for that which is so essentially a probability in a world so unstable economically.

The voice of our Government has been strong and vibrant about the necessity of maintaining our standards. It has been expressed in no uncertain terms by those who are today responsible for our safe navigation as a nation through the troublous and dangerous international sea.

We are struggling to maintain against the advocates of unpreparedness a force adequate to give us prestige in international council, to insure our continued prosperity at home and abroad, and to maintain our economic standards which are the mark of our civilization.

Now that, on our own initiative, a limitation has been placed upon size and numbers of certain types of vessels of war, it is more than ever incumbent upon us to provide for a strong and efficient merchant marine.

We can all still remember the cry that arose during the world war for "ships—more ships." We all remember how less than a year before that time a national political campaign was waged in part on the slogan "He kept us out of war." Behind the endorsement of that slogan was no doubt the conviction that we could still be kept out of war. Yet war did come to us, and the pleading cry of "ships—more ships" was heard from one end of the land to the other. That cry was not for more combatant ships—we were fairly well prepared in that respect—but it was a cry for more ships of the merchant marine. We needed them then to make our power effective in the war. We shall need them in the event of any war to make our combatant force effective in any theater of operations. They must exist for the logistic supply of the fleet. Without a continuous supply of fuel, of provisions, of ammunition, of war materials, your fleet is tied to your home ports and becomes an inefficient projectile of short range. With well-equipped and trained merchant seamen operating merchant carriers and acting as the supply train for the fleet, the Navy becomes what it is designed to be—the strong right arm of our country's defense.

But apart from the absolute need of a merchant marine in time of war, which is but an emergency use of it, we have a greater need of it in times of peace.

We need it to maintain the prosperity of our farms and our factories. That need is constantly growing; for we are now producers in farm and factory beyond our power of domestic absorption, and in order to maintain a decent economic standard in this country we must carry to foreign markets our surplus products. We should do this in vessels of our own register, flying our own flag and manned by our own officers and men. A positive national danger lurks in the complacent and sometimes expressed willingness to turn our carrying trade over to foreign companies. Why should America pay tribute to foreign carriers and revolt at the suggestion of a proper support to our own merchant marine? Why contribute to the strength of the sea forces of foreign powers at the expense of weakening our own? With a seafaring population unexcelled in the world, is it good American business not to employ it and train it so that it can join hands with the farm and the factory laborer to work as a well-organized team to maintain and guarantee our continued prosperity?

Without the merchant sailor and the merchant ship, the farm hand and the farm, the factory hand and the factory are without their proper and necessary support.

To deny a subvention that will give our merchant marine an equal chance with that of other nations will stultify the development of one of the greatest factors that will govern our future prosperity economically and our future national security.

To guarantee both our continued prosperity and our national security we must keep our Navy up to the highest standard of efficiency, and we must buttress it with a merchant marine that will be a pride to us in the pursuit of its mission in time of peace and be an added security to us in time of war.

ADDRESS OF BRIGADIER GENERAL WILLIAM WEIGEL, U. S. ARMY.

Mr. Toastmaster, Mr. Secretary, guests, and gentlemen of the Society, I assure you that if I had been aware of the fact that I was to be called upon to make a speech, I would have had something up my sleeve, like my dear friend, the Admiral. I think that the toastmaster saw that he had one "land-lubber" in your midst who could not very well get away, so decided to call upon me, or else he saw in me one of that remnant of the United States Army left after Congress got through paring it down.

The Navy has a great advantage over the Army in one respect, that is, no one, not even you gentlemen who have been long associated with the Navy, would think of going to Washington to ask the Secretary of War to appoint you admiral of the fleet or captain of a ship. The average layman looks upon a ship as a mystery and with fear; he does not want to tackle such a job. This is not so with the Army. We have too many "born Napoleons." You can find them on every corner, clamoring for command, in time of stress. What they lack in knowledge of the art of war or as tacticians, they count upon being covered up by politics or the press. Whether successes or failures, the press makes them heroes, and in time they, themselves, come to believe that they are such. They know how to get promotions, and when the medals are given out they know how to get them.

Now, gentlemen, I want to say one thing about our Navy. If we had never sailed our ships farther than along our coasts, and then scrapped them, the country would have been well repaid for the money spent in the development of the great industries which you gentlemen represent.

Our great industries in steels, in metals of all kinds, our improved production, would never have been at the stage of development at which it is at the present time, if it had not been for the exacting demands of the Navy in connection with the building of its ships and vessels.

I could go on and say many things about our sister service—it has always been good to me, it has always been good to the Army—and we of the Army are always inspired and proud whenever we see the old stack coming down the bay. I am going to give you one little instance.

One of the proudest days of my life was when dear Captain Hayes, the new chief of the fleet of the White Star Line, asked me for advice in regard to the sailing of his ship to the other side during the World War. He was captain of the Olympic when I put 9,000 of my command aboard at Pier 56, New York City, on May 5, 1918. He consulted me as to whether I wanted a convoy. I told him that he was master of the ship and that whatever he said went, and that he was to run the ship without any interference from me except to bring us into the war as quickly as possible with all reasonable thought for the safety of the troops. He stated that he did not desire a convoy, so we sailed without making any plans for such assistance. We pulled out about 2 p. m. on May 5, 1918, and made over 500 miles per day. On the morning of the 10th, as I was on the bridge with the captain, he looked through his glasses and said: "There they come; there are your destroyers." Pretty soon the fleet of destroyers arrived, and it seemed that every man of my command gave one great hurrah. Our men had been drilled daily in taking their proper places on deck with their life preservers and how to use the small boats in case of accident. At this

time the appearance of a hostile submarine was possible at any moment. It was an inspiring sight to see our destroyers moving about our ship like swallows, and Captain Hayes commented upon it to the effect that "he felt somewhat more secure now that this fleet had put in an appearance." It was certainly a grand sight to watch the maneuvering of our fleet of destroyers.

On the morning of May 11, at about 3.45, we got a big bump. I was nearly thrown out of bed, and, of course, looked for my life preserver and couldn't find it, although I required the men to carry theirs at all times. Mine had been left upstairs in the saloon. Next there was a raking alongside the ship, and I heard two reports of gun fire. About that time an officer came down to the cabin bringing the compliments of Captain Hayes, and said in effect that "everything was all right, General, we struck a German submarine, cut it in two, and are now proceeding on our voyage." Our destroyers picked up about fourteen survivors of this ill-fated submarine, which turned out to be the German U-boat 103.

We arrived at Southampton the next day where the Olympic was examined and found not to be damaged materially.

Upon my return to the United States after the war was over, I sailed from St. Nazaire on the good ship Pocahontas, formerly the German ship Princess Irene, with Captain John Downs of the Navy as master. When we were about halfway home Captain Downs asked me where I desired to land. I suggested New York Harbor. He thought that port would be somewhat congested, so we decided to run into Newport News. We landed there on June 1. The following day I received a telegram which had been waiting for me at Hoboken, demoting me from the grade of major general to my army rank as colonel. So, gentlemen, I had the pleasure of deferring this kind news for forty-eight hours by setting Newport News as the landing place. (Laughter and applause.) Before proceeding to Camp Dodge, Des Moines, Iowa, to demobilize my division, I went to Washington on the subject of my demotion, but there was nothing doing. I stated emphatically to the authorities that I did not mind demotion, so far as my army and navy friends were concerned, because they would understand it, but it was a pretty hard thing to explain to your friends on the outside of the service.

Now I wish to say a few words on the subject of ship subsidy. I happened to be in the Hawaiian Islands when I saw our merchant marine leave the Pacific. I recall distinctly how one by one they disappeared. It was a day of great sorrow and regret to our people, for we saw nothing but Japanese vessels and no American ships. At that time I asked myself the question: What is going to happen to this great country of ours? and ever since I have been watching this, and I only hope, gentlemen, for the good of our country, that it will reestablish our merchant marine in proper form and size. Then if we are called upon again to furnish transportation or convoys or supplies, we will have ships that we will not be afraid of sinking every moment because of the fact that we had to buy any "old tub" in an emergency.

We have the men, we have the materials, we have the products to ship and we have the wealth to make our country the greatest on sea in the world.

In my opinion, in regard to preparation for offensive and defensive action on the part of our Navy, reasonable preparedness is all that we ask, so that when a great national crisis occurs again we will not be trying to prepare in fifty weeks what we should have been doing for fifty years. (Great applause.)

THE TOASTMASTER:—If what we have heard is a fair sample of the speech that General Weigel can make when he does not know he is going to be called upon, what would you expect from him if he had notice and preparation.

Now, gentlemen, our last speaker is very dear to everyone in this room, and I presume there are few people who do not know him—at least all the people who are connected with the Society know him, and all his friends call him "Homer." Those of you who have not the pleasure of knowing him personally know him by reputation.

He is president of one of our greatest shipbuilding companies; he has been honored by very high positions, among them as president of the Chamber of Commerce of the United States, and he has been selected for very important public functions. I do not need to tell you much more about him, because his record is so well known. He is one of the best speakers that we have had the pleasure of hearing at our banquets, at which he has spoken at intervals, and I know that you will be entertained. I have great pleasure in introducing Mr. Homer L. Ferguson, president of the Newport News Shipbuilding and Dry Dock Company.

ADDRESS OF MR. HOMER L. FERGUSON.

Mr. President, Mr. Secretary and gentlemen, it seems to me that the General's efforts rather offset his argument. If a man can make that kind of a talk without preparation, why should not what is left of our Army make a real fight without preparation?

I have not prepared for my speech at all; in fact I broke up a portion of a ten-year holiday recently allotted to us to come up here and tell my friends and fellow-sufferers that it is not as bad as it looks. I am advising all the shipbuilders to shut up their shipyards in the hope that some of them will do it. That advice is similar to that given by a Yankee colonel luring the war to old John Murphy, a famous hotel man of Richmond, who was captured by this colonel. John was a very large man and a very heavy feeder, and after three days the colonel said to him: "Mr. Murphy, you will have to go home; I am damned if it is not more expensive to feed you than it is to fight you." And it is more expensive to keep going than it is to shut up, in the case of the shipyards at the present time. (Laughter.)

We shipbuilders have had our ups and downs—mostly downs—but we went up during the war. We were not on the firing line, on the field of battle, but we were on the firing line in this country, and a great industry which had been neglected for many years except by a few devotees, some of whom are here present, suddenly was magnified among all the industries in the United States and became one of prime and first importance. Nearly everybody crowded into it. Most of them have crowded out or have been crowded out, and we were told that, if American ingenuity and American manufacturing methods were applied to shipbuilding and we built them by the yard or mile or section or in some other way, we would make more satisfactory advance, but I notice, after a trial by the greatest American manufacturers, who thought they should apply those methods to shipbuilding, that they have finally given it up. They are building Fords or trucks or plows or something else, and they discovered what we men who operate shipyards are now discovering—that there is a vast and inherent difference between shipbuilding and manufacture. I do not know much about building cars, but I am frank to confess that it requires a considerable degree of effort to get enthusiastic about a coal car. I do not suppose that anybody ever loved a coal car, but I think we can learn to build coal cars, and we can beat swords into plowshares and spears into pruning hooks, but no man born and bred to the business of building ships ever tried to do these things before.

It is difficult to explain to business men, who look on profit as being the sole aim of business, that those who build ships and go down to the sea in ships have never engaged or continued in their vocations because of the profits which were involved in them, but to them it means an active and real thing.

So those of us who have gotten our ten-year holiday do not feel happy over it, but we are reasonably sure that we can make a living, and I tell you, gentlemen, to see a great plant, which it took thirty years to build up, lying idle does not make me feel very happy; it has rather a depressing effect.

At this table are six or eight men who, like myself—and most of them my seniors—were sent abroad thirty years ago to learn shipbuilding, because there existed in this country no institution which was considered equipped and fit to teach modern shipbuilding and modern marine engineering, and men of the Navy who were to design the construction of navy

vessels. It is true that we had some shipbuilders and we had some shipyards, but there are men who, like myself, put in the first years of practical work on the old battleship Texas, whose designs were purchased from British architects, and although they were fair designs, they are just about as good as the usual design, general in character, issued by a general designer, and the design sent to the shipyard and the ship built; and at that time, no public man in this country, from the President down, who settled this matter, but said what a shame it was that there should not be in the United States men who were just as competent to do this work as men in any other country.

The art of shipbuilding, which had almost died, was revived by that and other means. Many men not in government service went abroad to acquire knowledge of the art, and great hordes of men were brought here, and are still here, Scotchmen, Englishmen and Irishmen, and formed in many cases the nucleus of a working force, and the art of shipbuilding was revived and millions were put into these great industries, because our people wanted a navy and we built a navy.

At the end of the Great War we had in materials, in equipment, in men, in skill and in material resources, designed for the building of capital ships of war, facilities equal to the combined resources of probably the rest of the whole world, and we built at that time fifteen capital ships.

A conference was called in Washington for reasons perfectly proper and good to the President of the United States, and as the result of that conference the United States scraps eleven capital ships on which it has spent nearly $300,000,000, and another great country pledges itself to follow us in this matter and to scrap as many capital ships as we have, and for ten years the art of warship building is to be left alone.

The asset on which the trade was based was the ability of this country to do that thing, and in ten years, gentlemen, unless means are taken to replace the building of ships of war by other large ships—at the end of ten years, I say, the asset on which the trade was based will have been lost and the United States will be left powerless and advanceless upon the sea.

You cannot tell us, who built ships and repaired ships during the war, that we do not represent a vital and national industry. We know that it is vital; we know it is more vital than any other single industry. We know that only with ships can we communicate, in time of war and in time of peace, with the other countries of the world; and so I deem it our duty, regardless of whether we may be accused of selfish motives or not, to see to this thing—to see that unless the United States keeps itself in position to keep alive the art of shipbuilding and ship designing and marine engineering, at the end of this holiday we will have a prospect before us of a longer holiday.

I am getting to be one of the older men of the business now. It used to be, when we met at the functions of this Society, which was formed in 1893, I was one of the cadets. It is not unlikely that some of us who build ships feel, as a matter of fact, that we do not have to, that we can do something else (most of us did not make enough money out of the war to quit altogether, and I suppose that it is a fortunate thing for us we can do something else), but the art of the men who design and the men in our yards who have grown up with this great art is great, and I tell you that these men cannot be replaced. It took twenty or thirty years to make them competent to do their work.

This long holiday reminds me of my old friend Judge John Locke in Newport News, who had before him a bootlegger a short time ago. This bootlegger used to be a riveter with us, and he was caught with the goods—not light wine or beer, either—and he was

fined $150 and sent up for ninety days. He had a consultation with the judge about it. He had employed lawyers who took his money and fought the case, but he was convicted. He said: "Judge, I made a mistake; if I had just pleaded guilty in the beginning I do not believe you would have fined me more than $150 and would not have sentenced me for more than sixty days. I make the best liquor in this county, I double distills all my liquor and sells it to the best bankers and merchants in Newport News. I think they have enough to last sixty days, but I am afraid their supply will run out before the end of ninety days, and they will have to get another bootlegger." We might be satisfied with three or five years, but a ten-year holiday is a pretty long time.

This proposition of the merchant marine and the building of big ships is very much like building warships. The elements are practically the same—speed, power, size, equipment—and a knowledge of all of these things is necessary in a trained personnel. I hope, and every man in this room, I am sure, hopes that it will be made possible in some proper way for those who buy ships to operate them profitably, so that shipbuilding and ship operating under the American flag may continue.

We have a great many ships now, mostly nondescript; there are 300 in the James River, almost in sight of our shipyard, built during the war, good enough ships of their kind, but too much of a kind, something like a railroad with all coal cars, no passenger cars and no Pullman cars.

We have built some passenger ships with which you are familiar, and the operation of the ships is important, and I am sure that the gentlemen who are operating them now are doing the best they can with them. We have some of the most competent men in the industry handling these ships. Our interest in the shipbuilding industry is based very largely on the success of our customers. If our customers cannot operate successfully, we cannot build ships, because there will be no demand for them.

How is it that the merchants are generally favorable to protection, but in connection with one of the most necessary and needful industries in our country we are told we must not protect shipping. Why should we people who live in the United States, paying United States wages, not have the protection in an essential industry that other people have? I do not understand it. I do not understand the antagonism to it. I can see why a rank free trader would say, "and then we can compete," but we have not done that and are not going to have it. We folk down south do not want it—a few cotton planters do—but God Almighty in the beginning protected them and arranged it so that nobody else could grow the stuff. We do not want it, no business wants it, and yet we are denied this thing, and they say a subsidy is awful, digging into the treasury and all of that kind of talk. Some people tell me that they are willing we should have assistance if we will call it something else than subsidy. Why call it something else? Why not be fair to those who are sent out to represent the United States on the seas? Why put them bareback in the world when everybody else is protected?

There is no means of competing with the low wages in foreign countries under present conditions, and yet those who believe in preparedness, those who profess to believe in an army and navy, those who have, only a few years behind them, the great spectacle of a country utterly powerless except when it had been forced to prepare for its defense, and when we know there is a career before us in the world as a whole and room for our carrying trade overseas, tell us that we must not do anything for the merchant marine. They do

not say it in just that way, but they give excuses why it should not be undertaken in its full scope at the present time.

I can understand a misguided national pacifist opposing it, because his general theory is to oppose all active aggression, but I do not understand how American men and American patriots, who believe in preparedness, should neglect such an element in our general scheme of preparedness as the merchant marine.

During the war we needed the ships of the merchant marine far more than we needed battleships, as it happened, and of our army of 2,000,000 men who went to France, 500,000 went in U. S. ships, 500,000 in ex-German ships, and one million in the ships of our allies. Men speak of it in different ways and call it different names. Some speak of the law of nations; some speak of the Five Power Agreement of the English-speaking peoples. You gentlemen and I know that the great bulwarks of this world are Great Britain and the United States (applause) and, whether we will or not, we are partners in the enterprise of keeping the world on an even keel and on its feet, so not only to the members of this Society but to all our guests from abroad I would bring this message—if we are to be partners in this great enterprise, it is necessary, gentlemen, that we be partners in deed and in truth, as well as in name, and if we are to be partners in deed and in truth, it is necessary for the continuance of this partnership that we have the rights of partners, that each of us be as independent of the other as we may well be. You and I cannot be partners in business if I am dependent upon you to take care of me—that kind of partnership is not a lasting partnership.

Whether it happens this year, or in the year to come, that the bill pending in Congress shall be adopted, I tell you, as sure as we are assembled in this hall, the United States will go upon the seas and will stay upon the seas. It is not within the power of any man or any set of men to deny that. The spirit of our forefathers filled them with adventure and sent them here, and the spirit of their sons, if they are worthy of their sires, will send them to the four corners of the earth, and will send with them, to care for them, to protect them and defend them, the flag of their country, flying on their own ships. (Loud applause.) Gentlemen, that is the worthy observation, it is a noble aspiration, and that is what we would have our sons do, and those who are wise and who will consult their own best interests will try to make it possible for us to get upon the seas, will not consider it an offense, will not consider that we are invading anybody's rights or privileges. We are a great country, with a great and growing commerce, we are bound to go abroad, and we will go into the commercial No Man's Land. In that connection we have certain inherent rights, one of which is to carry our goods in fair share, and whether it comes by subsidy, which I look on as being largely temporary, or in some other way, it will come, regardless of what any publicist or publisher may say.

I believe in the United States as you believe in the United States. It is a great country—God Almighty made it great, and men have helped to make it greater. Our future lies largely upon the sea, and the heritage of the sea shall be ours, as we deserve it, and we will carry a fair share of our own trade to the ends of the earth.

I believe it is right, and I believe that right-minded people will agree with that proposition.

Some say that an artificial aid is to help you get started. I do not think it is necessary to tell you that the economists are not the only people who are taking a hand in the operations of the world. We hear much about supply and demand; the chief factor, gentlemen, the greatest modern factor in business is trial. How can you pay when you have not

really started well yet? You must become established, and as Mr. Love has told you it is necessary to demonstrate strength in order to secure respect and receive the same fair treatment that others receive.

There is one other point, and then I am through. You know that most of us down our way are Democrats—that is, we are Democrats by inheritance—some of us vote the national Republican ticket and usually vote the local Democratic ticket. We still have the color question before us, and we neglected to tell you the other day that there is going to be another election in which you Republicans will be interested, and we will not neglect it next time, and I am sorry that we overlooked it this time. But I want to say this, speaking for our people, that we have the greatest respect for the President of the United States and are pleased and proud in our business that at least we have a President who is a friend of ours—the only President in my time who has known about the merchant marine, and with no selfish object in mind has championed it, and stands back of it, and has determined that in his administration such laws shall be written into the statutes of the United States and such aid given relating to shipping to mark that probably as the one outstanding feature of his administration. (Applause.)

I can assure you gentlemen who have not had the pleasure of talking to him about it that his heart is in it, that he is our friend in these days of dull times, when building is poor and repairing is poor. We are to be congratulated that we have a friend at court who does not have someone else to write his messages about the merchant marine, but who believes in it and is devoted to it, and so, as a Southern Democrat-Republican, we are pleased and proud that Mr. Harding is our President at this time. (Applause.)

THE TOASTMASTER:—Colonel Simmons asks me to announce that tomorrow morning in the auditorium of the American Marine Association there is to be a meeting in relation to standardization at 11.30 o'clock, and the meeting will continue at 2.30 o'clock on Friday and also at 2.30 o'clock on Saturday.

I think you will all agree that we have been highly entertained tonight with these magnificent addresses and that it has been well worth while for us to be here. We want to express to Secretary Denby our thanks for his splendid speech and ask him to convey to President Harding our sincere thanks for his message.

Now I shall bid you all good-night.

The company then dispersed.

Obituary

ARTHUR WHITTIER AYER

MEMBER

Mr. Ayer was born near Boston, Mass., October 16, 1867. He was a graduate of the public schools and Massachusetts Institute of Technology, Class of 1890. After graduating he was employed by the Pneumatic Dynamite Gun Company of New York in 1890 and 1891 and also served for a short time as assistant at Massachusetts Institute of Technology.

In 1891, he established the Department of Mechanical Engineering at the University of Vermont, and in recognition of his work there the university later conferred on him the honorary decree of M. E. When Professor Ayer, in 1902, left the University to engage in commercial operations, he bequeathed to his successor a well-equipped department and a well-rounded curriculum. Futhermore, his interest in the institution did not wane after his withdrawal, but was repeatedly manifested. The many students who profited by his thorough knowledge and by his effective method of presenting his specialty will not cease to remember him.

From 1902 to 1922 Professor Ayer had been engaged in commercial work, first as superintendent of the vast Philadelphia plant of Harrison Brothers, and later as founder and proprietor of the Midland Chemical Company of Chicago, which manufactured certain paint specialties.

Professor Ayer's outstanding traits, which won him a host of friends, were his simple directness of character, his large capacity for genuine friendship, and his quiet forcefulness. He became a member of this Society in 1899, and his death occurred at La Grange, Ill., on December 4, 1921.

WILMON HARLAN BENSON

MEMBER

Mr. Benson was born at Wilmington, Del., August 23, 1881. He came from a line of shipbuilding men, his father, Nathaniel R. Benson, having been superintendent of the shipyard of Harlan & Hollingsworth for a number of years and Mr. N. R. Benson was preceded by his father. His grandfather on his mother's side was senior member of the firm of Harlan & Hollingsworth. Mr. Benson entered Cornell University in 1899, but was compelled to leave in the middle of his freshman year because of the death of his father. He then went into the drawing room of Harlan & Hollingsworth Company, where he remained until 1905. On August 5 of that year he entered the hull drawing room of the Newport News Shipbuilding & Dry Dock Company. He held various responsible positions with that company

for twelve years, and during his term of service there many important ships of the U. S. Navy were built.

Mr. Benson in 1916 became affiliated with the Bethlehem Shipbuilding Corporation, Fore River Plant, Quincy, Mass. On April 9, 1917, he was made superintendent of hull construction. On the outbreak of the World War, when the United States erected the Victory Plant at Squantum, Mass., for the construction of destroyers, Mr. Benson was selected to take charge, where a world record was made in destroyer construction.

Since 1921 Mr. Benson had been sales agent of the Fore River Plant of the Bethlehem Shipbuilding Corporation with an office in Boston. He also had charge of the repair work of which Fore River had made a specialty since the construction of its huge floating dry dock.

Mr. Benson became a member of this Society in 1914. He died June 18, 1922, as the result of an automobile accident.

EDWIN AMBROSE BURNSIDE

MEMBER

Captain Burnside was born at Middleport, Ohio, May 17, 1864. At the age of fourteen he entered the employ of the Campbell's Creek Coal Company, Point Pleasant, W. Va., as a cabin boy and continued with that company for forty-four years, serving in various capacities up to the time of his death, when he was manager of transportation. Since 1894 he had been engaged as captain of the steamers of the company, also in the construction and repair of steamers, towboats, etc., and in the design of hulls, engines and boilers for service on western rivers. He had no technical training, his experience being all practical, and he improved his knowledge of shipbuilding and kindred arts by his membership in various technical societies and his study of their transactions as well as marine journals and books on shipbuilding.

Captain Burnside was an authority on the question of Ohio River matters and a leading spirit in the work of the Great Kanawaha Improvement Association. This association at his death passed a resolution stating among other things as follows:

"He unstintedly gave of his time and talents to the enlargement and upbuilding of river traffic, and without a doubt had a larger and more complete knowledge of the necessities for the development and improvement of rivers than any other man on the western waters."

Captain Burnside met his death by drowning on March 16, 1922, when the towboat Helper, owned by his company, capsized in a flood on the Ohio River. He was elected a member of this Society in November, 1911.

SIR GEORGE JOHN CARTER, K. B. E.

MEMBER

George John Carter was born at Gosport, England, on May 24, 1860, and served his apprenticeship as a shipbuilder at the Portsmouth Dockyard, and continued to work in the drawing office there for four years after completing his apprenticeship. In 1886 he joined

the firm of Sir W. G. Armstrong, Whitworth & Co., and in 1894 was appointed shipyard manager at their Elswick works. Whilst at Elswick he was largely responsible with the late Mr. Perrett for the laying out and equipment of the Armstrong Naval Yard at Walker-on-Tyne. Among the ships built at Elswick during his period of management were the Superb and Monarch and the battle cruiser Invincible, while among foreign warships the Brazilian battleship Minas Geraes was perhaps the most notable.

He was, while at Newcastle, a member of the Tyne Improvement Commission and senior major of the 1st Northumbrian R. F. A. (T. F.).

In October, 1912, he became managing director of Messrs. Cammell, Laird & Co.'s shipyard at Birkenhead, and he continued to occupy that position until the time of his death. In addition to his duties as managing director at Birkenhead, he was a member of the Mersey Docks and Harbor Board, and served as President of the Shipbuilding Employer's Federation in England from November, 1915, to September, 1919. During the war he was chairman of the Merchant Shipbuilding Advisory Committee, a post of great responsibility which he filled with conspicuous success. He was also vice-chairman of the Liverpool Munitions of War Committee and served on the Council of the Federation of British Industries and on the Technical Committee of Lloyd's Register.

He was a member of the Institution of Naval Architects, which he joined in 1889 and served on the Council from 1913 onwards.

In August, 1917, the honor of Knight Commander of the Order of the British Empire was conferred upon him.

Mr. Carter was a member of this Society since 1899. He died February 9, 1922.

CREIGHTON CHURCHILL

MEMBER

Mr. Churchill was born in St. Louis, Mo., September 9, 1866. Entering the U. S. Naval Academy in 1881, he graduated in the class of 1887. On June 30, 1896, he was forced to retire owing to injury to his eyesight incident to service. He was called back to active service under special legislation in 1899 and remained in the Navy until 1907, when he was again placed on the retired list.

Mr. Churchill then engaged in mechanical and industrial engineering, specializing in the latter for eight or nine years, and had been employed by the General Electric Company, Lynn, Mass., and the American Brake Shoe & Foundry Co., Erie, Pa. Mr. Churchill, on the outbreak of the World War in April, 1917, was ordered back into active service at the Navy Yard, Boston, Mass., where he was employed as shop superintendent in the Machinery Division, until July 10, 1918, when he became chief of the Standard Practice Branch, Emergency Fleet Corporation, at Philadelphia. He remained in this position until November 29, 1919, when he resigned owing to completion of the work.

Mr. Churchill in 1920 became general superintendent of Rumsey Pump Company in Seneca Falls, N. Y. His health broke down in July, 1921, forcing him to give up business, but after a few months' rest he accepted a position with the Sidney Blumenthal Company in Derby, Conn., where he died May 28, 1922. He became a member of this Society in 1918.

HUIBERT COP

MEMBER

Professor Cop was born in Deventer on the 9th of November, 1853. At the Polytechnic School in Delft, he chose in 1873 to study for mechanical engineer and passed his B examination, after studying only two years. The Dutch Government having promised a liberal college allowance to an applicant for the vacant position of naval engineer, provided he obtained within two years successively his diplomas for shipbuilding and mechanics, Professor Cop presented himself for the vacancy.

In 1877 he obtained the first-mentioned certificate and was appointed naval engineer and allowed to continue his studies in Delft. After one year he obtained the certificate of mechanical engineer and was appointed at the governmental shipyard in Amsterdam. After two years' service in Amsterdam he was advanced to second class engineer and embarked, in the latter part of 1880, on board the screw-steamer Leeuwarden, one of the units of a squadron, which successively put in at Madeira, Teneriffe, Paramaribo, Lissabon and several ports on the Mediterranean.

After his return he worked a few months at the governmental shipyard in Willemsoord, and later in Amsterdam, where he was the assistant of the principal consulting engineer from 1883-1887. In that function he supervised the building of the police vessel Zeemeeuw, the steamer Condor for the Royal Navy, floating drydocks for Sourabaua and the screw-steamers Flores, Reiger and Lucifer, destined for the service in the Dutch Indies.

In 1887 he was entrusted with lecturing on scientific shipbuilding at the Polytechnic School in Delft, and on the first of the following year he was appointed professor in that branch. When the appointment was made he had been recommended as one of the most capable and industrious members of the corps of naval engineers. He remained on the list of that corps *pro memorie,* and in 1887 he was promoted engineer first class.

Professor Cop lent powerful assistance to all efforts made in the Netherlands in order to complete a modern installation which would enable one to apply methods of testing ship models by means of a tank. His assistance in that direction culminated during his membership of "Staatscommissie Sleeptank" established in 1918. In this commission he was one of the most industrious members. On one of his scientific trips he visited in 1919 the tanks in London and Paris. He thoroughly realized the limits of practicability and insufficiency of this otherwise indispensable method, and considered the building of a tank above all things desirable in the interest of the industry to solve concrete questions.

Professor Cop, as a teacher, tried to cultivate in his pupils clear notions and a real zeal for study, by showing and explaining to them the work of the most advanced examiners and engineers. He gave no prescription of his own, but desired to develop the critical acumen of his hearers and to give them an opportunity to form their own opinion.

The Dutch Government recognized his merits by bestowing upon him the decoration known as Knight of the Order of the Dutch Lion (Orde van de Nederlandsche Leeuw).

Professor Cop became a member of this Society in 1900. He died December 8, 1921.

JOHN DE MORANT CRAWFORD

ASSOCIATE

Mr. Crawford was born October 6, 1876. After taking a special course in naval architecture at Cornell University in 1902 he entered the employ of the Wm. Cramp & Sons Ship & Engine Builders Company, Philadelphia, where he remained several years, being employed in various departments of that company. On August 5, 1910, he became inspector under the district engineer, Mississippi River Commission. He was later promoted to overseer with local charge of the construction of the steamer Chalmette and of some barges. After the completion of the work he was assigned to the duty of levee construction. He became a member of this Society in 1917 and died May 9, 1921.

JAMES DICKIE

CHARTER MEMBER

James Dickie was born at Arbroath, Scotland, on March 12, 1847. Coming from a family that had been shipbuilders in Scotland for generations, and inheriting the instinct of a shipbuilder, Mr. Dickie started work at a very young age and learned to make with his own hands everything pertaining to small craft, including wood hulls, small boats, blocks, spars, rigging, fittings, etc. Without the advantage of a college education, by constant self study and reading he acquired a breadth of knowledge in science, art, and literature which might well be envied by many more fortunate ones.

In 1870, with his father, mother, and one brother, James Dickie moved to San Francisco and soon became an important factor in Pacific Coast shipbuilding. The other brother, George W. Dickie, came to California two or three years previously.

In partnership with his brother, John W. Dickie, under the name of Dickie Brothers, he built many successful wood, sail and steam vessels.

One of the vessels, the Mexico, the largest wooden passenger ship built on the Pacific Coast, iron strapped and powered for 13 knots, was the pride of both owners and builders.

In 1884 the Union Iron Works, which had conducted a general heavy and mining machinery manufacturing business since 1849, added a steel shipbuilding plant and appointed James Dickie as superintendent, in which capacity he continued until 1904. Mr. Dickie's most important work was accomplished in the construction of warships during this period when the Arago, Charleston, Olympia, Oregon, Ohio, Monterey and some of the American-Hawaiian ships were constructed. When the Oregon was built he was manager of the shipyard of the company.

James Dickie's chief contributions to the subject of naval architecture were along the line of improved methods of handling material with cranes and in launching, and his papers, "Overhead Cranes, Staging and Riveter Carrying Appliances in the Shipyards," Volume 7, and "Launch of a Cruiser and a Battleship,"Volume 8 of the Transactions, are valuable contributions to those subjects. Soon after retiring from the Union Iron Works, he opened a consulting naval architect's office. His health gradually failed, and for the last four or five years he was practically helpless. His mind and interest, however, remained keen and clear up to the last.

By his death, April 22, 1922, the Society loses one of its charter members, and one who was a unique figure in the shipbuilding industry on the Pacific Coast until his health forced him to retire.

JOHN ADDIE DONALD

ASSOCIATE

Mr. Donald was born at Kirkintilloch near Glasgow, Scotland, July 24, 1856. He was educated in the grammar and high schools of Scotland. He began business life with John R. Young & Co., ship brokers. His early experience, after spending a year or two in Italy, was with the firm of Walker, Donald & Co., of which his brother, the late James Donald, was a partner. This firm was engaged in the shipbuilding business from 1875 to 1888. In connection with this business Mr. Donald came to the United States in 1884, where he looked after the interests of a number of the steamers of his firm, which were engaged in the fruit trade between New York and Central America.

Mr. Donald in 1897 became interested in shipowning and purchased his first ship in that year. In 1902 he formed and became president of the Donald Steamship Co., New York. Mr. Donald gained further shipping experience as a director of the Atlantic Fruit Company.

When in 1917 Secretary of the Treasury McAdoo insisted that Mr. Donald become a member of the U. S. Shipping Board, it was undoubtedly with a feeling of patriotism for the country of his adoption that prompted Mr. Donald to relinquish a very profitable business connection in order to devote himself to the responsible tasks which fell on the shoulders of members of the Shipping Board.

Mr. Donald was the only member of the original Shipping Board having experience in the shipping business. His work on the board was most important. He was particularly charged with supervising the repairing and fitting out of the German and Austrian ships which were lying in American ports and were seized by the Government after they had been severely damaged by their original crews. He was also placed in charge of the recruiting service, the Ship Protection Committee, and of the Ship Operating Committee.

Although taking up public office at a time in life when he could have retired and spent the remainder of his life in ease, he devoted his untiring energy to the needs of the country in shipping, which became of such vital importance during the war. His many years of experience proved of inestimable value to the Government in the performance of the responsible duties which were thrust upon him. Throughout the entire war and until the end of his term he devoted his time, energy and health to his country's demand. Many men, much younger than he, broke down under the terrific strain of public duties in those days, when the best each man had in him was required in the interests of the nation. Mr. Donald left office with his health shattered but with the consciousness of having performed his part in the great conflict to the uttermost of his ability. It was frequently a cause of wonderment of his confrères how he could bear up under the burdens which were placed upon him. His death at a time when he should have been enjoying a well-earned rest marks Mr. Donald as one of the sacrifices of the Great War as truly as though he had fallen on the fields of Flanders. Mr. Donald was well and favorably known to the shipping public throughout the land. His patriotism and courage were inspiring to those associated with him. His genial disposition and his unfailing willingness to help all who applied to him for assistance

will be greatly missed by his hosts of friends. His mortal remains were interred with appropriate ceremonies in the old Moravian cemetery, on the side of Staten Island hills, overlooking the sea, which he loved so well.

He became a member of this Society in 1919 and died January 13, 1922.

DAVID FARIS

ASSOCIATE

Mr. Faris was born in Wheeling, W. Va., on May 20, 1878, and was educated in the public schools and at the Linsly Military Academy in Wheeling, from which he graduated in 1896, going to work almost immediately for the Bellaire Steel Works, Bellaire, Ohio.

At the outbreak of the Spanish-American War he joined the Army and went to the Philippines. Upon his discharge in 1899, at the end of the war, he took a course in the Elliot Commercial School in Wheeling and then came to Pittsburgh to work in the purchasing department of the National Tube Company. In 1901 he entered the employ of the National Cash Register Company in Dayton, Ohio, and a few months later became connected with the engineering department of the Pressed Steel Company in McKees Rocks, Pittsburgh.

In May, 1904, he was employed in the production department of the Westinghouse Machine Company, at East Pittsburgh, and later was transferred to the sale department, where he remained for five years. He then was assigned to the Atlanta office as sales engineer, and later was engaged in the Chicago office. In 1912 he was given charge of the Detroit and Indianapolis offices of the Westinghouse Company. When the Westinghouse Machine Company was absorbed by the Westinghouse Electric and Manufacturing Company in 1915, Mr. Faris returned to East Pittsburgh and was made assistant to the manager of the power department of the company. In 1919 he became assistant manager of the marine department, in which position he remained until his promotion, on July 1, 1922, to be manager of that department.

He became a member of this Society in 1920. His death occurred in his office at the East Pittsburgh works of the Westinghouse Company, July 10, 1922.

RICHARD JAMES HALL

ASSOCIATE

Mr. Hall was born at Philadelphia, Pa., November 15, 1893. He was educated in the Philadelphia High School and took an evening course in naval architecture at the Franklin Institute, Philadelphia, and also a course in marine engineering. He was employed by the New York Shipbuilding Corporation from July, 1911, to August, 1916, and entered the employ of the Sun Shipbuilding Co., August, 1916. Later he became assistant to the chief draughtsman. Mr. Hall was lost at sea on the morning of February 8, 1922, in the burning of the S. S. Northern Pacific, which was totally destroyed by fire off Cape May, N. J., while being taken from Hoboken, N. J., to the yard of the Sun Shipbuilding Company, at Chester, Pa., to be reconditioned for the Pacific trade.

PIERRE OTIS KEILHOLTZ

ASSOCIATE

Pierre Otis Keilholtz was born in Baltimore, Md., on April 22, 1862, the son of Otis and Emily Keilholtz.

After preliminary preparation in schools in Baltimore, he entered the U. S. Naval Academy, Annapolis, Md., on October 1, 1880, as a Cadet Engineer. In August, 1882, by operation of law, the Cadet Midshipmen and Cadet Engineers were consolidated, and Cadet Keilholtz became a Naval Cadet in the consolidated Corps of Cadets. He graduated with credit in June, 1884, but resigned shortly thereafter to enter Johns Hopkins University for a special post-graduate course.

After two years at Johns Hopkins in post-graduate electrical work, Mr. Keilholtz became identified with the Electric Light, Power and Street Railway Corporation, of Baltimore, being soon placed in responsible charge of design, construction and operation work. He remained with this corporation until 1907, when he established himself in private practice as a consulting engineer.

Mr. Keilholtz established, while at the Naval Academy, a fine reputation as a painstaking, thorough student, and was a man of unusual force of character and personal attraction. After leaving the Navy his career as a scientific and practical electrical engineer was a notable one. His reputation and influence in the community in which his life and work were thoroughly known and appreciated is well expressed in an editorial in one of the leading Baltimore papers—the *Baltimore Sun*—which in commenting on his death referred to him as follows:

"A man of originality of thought as well as commanding authority in his profession, Baltimore has reason to lament sincerely the loss of a citizen who truly loved his native town, and who was always ready to devote his talents to its material welfare and development."

Mr. Keilholtz was a Charter Associate Member of the Society of Naval Architects and Marine Engineers, and, while not often a direct contributor to its transactions, was always interested in its work and gave it his support through continued membership up to the end.

Mr. Keilholtz was also a member of the American Institute of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Naval Engineers, American Society for the Advancement of Science and other scientific organizations and social clubs. During the World War Mr. Keilholtz served as Recruiting Officer for the Army in the Baltimore area.

Mr. Keilholtz died at Baltimore, Md., on January 21, 1922, after a very brief illness. He is survived by his widow, Helen Cecelia Gerker Keilholtz, whom he married in January, 1900, and by his daughter Cecelia; also by a sister, Mrs. Thompson, of Fanwood, N. J.

ANDREW MACFARLANE

MEMBER

Mr. Macfarlane was born in Sunderland, England, on March 17, 1882. He served his engineering apprenticeship with William Doxford & Sons, Sunderland. After completing

his apprenticeship he was continuously engaged in the design, construction, operation and maintenance of ships and their machinery at Messrs. William Doxford & Sons, Parsons Marine Steam Turbine Co. and Wallsend Slipway and Engineering Co., and at the time the Mauretania was built Mr. Macfarlane was engaged for two years at the Wellsend slipway in connection with the designing and installing of her engines.

Mr. Macfarlane was a graduate in Marine Engineering of Armstrong College, Newcastle-on-Tyne and for four years was lecturer in Marine Engineering at the Sunderland Technical College.

About 1913 Mr. Macfarlane came to New York and worked for the Todd Shipyard Corporation as estimator for one year.

In 1915, he began business for himself as consulting engineer and ship surveyor and at once became prominent in shipping circles.

During the war, Mr. Macfarlane rendered invaluable services for the Allies by his untiring work in connection with surveys and arranging for and superintending repairs. He was also retained on the staff of surveyors by the United States Government in taking over German vessels in New York Harbor in 1916.

Mr. Macfarlane designed, arranged contracts and superintended the construction of hull and machinery for vessels of different types, varying in size from 3,500 tons deadweight to 10,000 tons.

In 1919 Mr. Macfarlane went into partnership with Mr. John Garmey, former superintendent of the Prince Line. In the same year Mr. Macfarlane was appointed consulting engineer for the Norwegian American Line in the United States, in which capacity he was in charge of much important work.

Mr. Macfarlane was courteous in demeanor, of sterling character, and his wide professional experience earned for him the esteem and respect of shipbuilders and engineers, as well as all with whom he was brought into contact.

Mr. Macfarlane became a member of this Society in 1916, and died September 17, 1922.

FRANK SPRAGUE MARTIN

MEMBER

Mr. Martin was born in Barrytown, New York, on May 13, 1852. His father, Captain Francis A. Martin, having followed the sea and having been also until his death a member of the American Bureau of Shipping, one of its council and surveyors and as well for some years a member of the Board of Trustees of Sailors Snug Harbor, it was natural for Frank S. Martin, after obtaining his education in the Free Academy, now the College of the City of New York, to turn his attention to ships and shipping matters. He served 1869 to 1877 in the designing rooms and yards of John Roach and Son at Chester, Pa., and Harlan and Hollingsworth Co. of Wilmington, Del. About 1877, he returned to New York to open an office in this city, thus founding the business of surveying, designing, appraising and superintending the building of ships of all classes.

It was due to his experience during this long period that Commissioner Donald, of the United States Shipping Board, made him on April 7, 1917, chairman of the Board of Survey and Consulting Engineers appointed by the Shipping Board for the immediate

purpose of taking direct charge of repairing and reconditioning the seized German and Austrian ships. These ships the crews had previously endeavored to destroy or damage and thus prevent their use by the United States in case war was declared upon Germany.

Following this he organized for the Government the operating company under which these ships originally were used in its service.

Many other important matters were pressed upon this Board of Survey and Consulting Engineers from time to time during the period of the Great War. Mr. Martin was also, for the Shipping Board, one of the three members of the Ocean Advisory Board on Just Compensation.

During all of his long business career, and especially by his valuable services to the United States Government, he attained an international reputation for faithful service to all clients.

Owing to his many years of conscientious and efficient duty as a marine surveyor and appraiser, Mr. Martin's testimony was frequently sought in important maritime litigations, where it was received almost universally as authoritative and conclusive by both parties to the contests. During his career in New York and elsewhere throughout the country, maritime suits involving many millions of dollars have been decided largely upon his professional advice and opinions. Mr. Martin's judgment and opinions in all maritime matters have not only been authoritative but synonymous with fairness and justice.

Mr. Martin became a member of this Society in 1912, and died July 27, 1922.

EARL PORTER MASON

MEMBER

Mr. Mason was born May 18, 1876, at Providence, R. I. He was educated at Moses Brown School, Providence, and Providence High School, spent one year in France, then entered the Massachusetts Institute of Technology and graduated, class of 1897. After graduation he entered the employ of the Eastman Kodak Company. In 1898 he became superintendent of the experimental department of the Draper Company (textile manufacturers), Hopedale, Mass. In 1902 he became secretary and superintendent of the Newport Engineering Works.

On March 10, 1917, he was appointed a lieutenant, U. S. N. R., and detailed as engineer officer at the Naval War College, Newport, R. I., being later ordered to New York as material officer, N. O. T. S. He was promoted to lieutenant commander and commander in 1919, being assigned to the Commission to Return Dutch Ships. He went to Holland with the commission and returned to America in October, 1919. He was relieved from active duty with the Navy at his own request December, 1919.

Commander Mason immediately became connected with the U. S. Shipping Board in charge of maintenance and repair at the New York District. He resigned from the Shipping Board May, 1920, going with the Anti-Corrosion Engineering Company of New York as production engineer, November, 1920, where he remained until his death August 14, 1922. He became a member of this Society in 1920.

FREDERICK METCALF

MEMBER

Mr. Metcalf was born in Providence, R. I., January 31, 1886. He graduated in 1890 from the Massachusetts Institute of Technology, in mechanical engineering. After graduation he was employed by the Rodney Hunt Machine Company, at Orange, Mass., builders of turbine water wheels. In 1892 he entered the employ of the American Ship Windlass Company, Providence, R. I., and was successively chief draughtsman, superintendent and treasurer. In 1898 he moved to Cleveland, where he became treasurer of the Chase Machine Company and vice-president of the Madison Foundry Company.

During the World War Mr. Metcalf was accorded signal appreciation by the British Admiralty for permitting the use of the winches of his company in boom defenses against submarines. Several thousand were used, for which the company asked and received but a nominal royalty.

Mr. Metcalf was a quiet and unassuming man, who was held in the highest esteem by all whose privilege it was to know him, for his integrity, kindness and strength of character.

He became a member of the Society in 1909 and died December 8, 1922.

MARK RICHARDS MUCKLE, JR.

MEMBER

Mr. Muckle was born on March 3, 1857, in Philadelphia, and was educated in private schools of that city. He served his apprenticeship with Wm. Sellers & Co., and later was a member of the firm of Ferrell & Muckle, machine designers and pump manufacturers. In 1912 he became head of the M. R. Muckle, Jr., & Co., consulting and contracting engineers. Mr. Muckle was a charter member of this Society. He died May 19, 1922.

SAMUEL LEON NAPHTALY

MEMBER

Mr. Naphtaly was born in San Francisco, November 20, 1874. He was educated in the public schools of San Francisco and the University of California.

After leaving the university he entered the service of various gas, light and power companies operating in San Francisco and during his time was engineer of some of California's principal electrical projects.

At the time of the San Francisco fire in 1906 he was general manager of the San Francisco Gas and Electric Company, and in the chaos that followed the fire, with all the wires down and with the generating plants destroyed, he performed a great feat of business reorganization when he hastily organized his workers and reopened the plants, repaired the lines and brought light and power again into the city.

In 1907 he became general manager of the City Electric Company, which capacity he

filled until the company was taken over by the Great Western Power Company in 1912, when he went with the combined companies as general manager. In 1912 he constructed what is known as the Lake Almanor Project in Plumas County, and which is today the chief reservoir of the Great Western Power Company.

Mr. Naphtaly was also one of the projectors and also the first vice-president of the Oakland and Antioch Railway, now known as the San Francisco and Sacramento Railroad Company, and was largely responsible for the engineering and construction features of this project until 1917.

In 1917, together with other business associates, he organized the Los Angeles Shipbuilding and Dry Dock Company and took an active part in the construction of the plant at San Pedro, Calif., and served this company as vice-president and general manager until December, 1921. A large measure of the success which the Los Angeles Shipbuilding and Dry Dock Company has enjoyed was due to his engineering skill and business acumen.

In January, 1922, he again entered the services of the Great Western Power Company in San Francisco and was vice-president and general manager until his health failed and he was forced to retire. After an illness of three months, he passed away in San Francisco, June 25, 1922. Mr. Naphtaly became a member of this Society in 1921.

NICHOLAS FLETCHER PALMER

MEMBER

Mr. Palmer was born in the City of New York, February 26, 1847. He was educated in Clark Street Grammar School, Eighth Ward, from which school he graduated in 1861 to the "Free Academy," now known as the College of the City of New York.

He commenced his business career in Wall Street with a firm of bankers and brokers in 1864 and rapidly made himself well and favorably known in financial circles, but in 1873 his father-in-law, George W. Quintard, a well-known citizen of the City of New York and an incorporator of the Society of Naval Architects and Marine Engineers, persuaded Mr. Palmer to join him as a partner in the Quintard Iron Works at the foot of East Twelfth Street, where, during the Civil War, were built a number of the gunboats of that period, including the monitor Onondaga.

When the so-called "New Navy" of iron and steel ships was inaugurated, the Quintard Iron Works, under the management of Mr. Palmer, the firm having become N. F. Palmer, Jr., & Co., built for the United States Navy the machinery of the armored cruiser Maine (subsequently destroyed in Havana Harbor, 1898), and the gunboats Marblehead, Concord and Bennington, as well as for many privately owned steamships, public water works and cement works. In 1904 Mr. Palmer changed the firm into the corporation, Quintard Iron Works Company, which was finally disposed of in 1917.

In 1898, Mr. Palmer, besides being the head of the Quintard Iron Works, became, as well, the president of the Leather Manufacturer's Bank, of which his father had previously been president for many years. Finding the two occupations too onerous, he resigned as president of the bank in 1902, remaining, however, to be an influential director for a number of years of the Mechanics and Metals National Bank, which succeeded the Leather Manufacturer's Bank. In 1901 he founded the firm of Palmer & Co., bankers and brokers.

Among many other important matters in which he was much interested, he was a trus-

tee of Webb Institute of Naval Architecture for the sixteen years prior to his death. He was one of the "1893" members of the Society of Naval Architects and Marine Engineers.

To all of these interests he was most faithful and his counsel of great importance. He will be remembered by all who knew him as having been the cheerful, conservative, courteous gentleman and friend whom it was an especial pleasure to meet.

He died of pneumonia on January 18, 1922.

WILLIAM STEELE ROGERS

MEMBER

Mr. Rogers was born December 25, 1859. He entered the service of the Fall River Line, June 21, 1879, and remained with this line and the other lines of the New England Steamship Company continuously from that date until his death on October 8, 1922, a period of over forty-three years. After serving in various capacities on the steamers and in the repair shops of this company, he entered the drawing room, where he was successively draughtsman and chief draughtsman. He assisted in the design and construction of its various new vessels, among them the steamers Puritan, Priscilla, Plymouth, Providence, Commonwealth, Bunker Hill, Massachusetts and Old Colony. In addition to the above work he designed and superintended construction of various steamers built by the Boston, Revere Beach & Lynn Railroad, Nantucket Steamboat Company, and others. He became a member of this Society in 1910.

CHARLES LINCOLN SEABURY

MEMBER

Mr. Seabury was born at Tiverton, R. I., on August 4, 1860, and at an early age began work in the marine store of A. B. Babbitt at Tiverton, later going to the Herreshoff Yacht Works at Bristol, R. I. From there he joined the Gas Engine & Power Company as Superintendent and Chief Engineer. This company was then builders of small boats. Here he was instrumental in developing the naphtha engine, forerunner of the gasoline motor. In 1889 Mr. Seabury established the Charles L. Seabury & Company, with William J. Parslow, and Jas. M. Colvin as partners, located at Nyack, N. Y., to carry on the construction of high-speed steam yachts. During this period of his career he produced the Seabury Safety Water Tube Boiler, which was and still is used where high steam pressures and quick steaming are required.

In 1896 his company business was consolidated with the Gas Engine and Power Company, at Morris Heights, N. Y., and for many years he acted as vice-president and general superintendent engineer of this corporation, which was the Gas Engine & Power Company and Charles L. Seabury & Company, Consolidated. In addition to yacht work, several torpedo boat destroyers and gunboats for the United States Navy were built at the yard. During his career, more than 2,000 vessels were designed and built, including the Embla, Kanawha, Hiawatha, Allegro, Vitesse, Little Sovereign, and Sovereign, the latter having a record speed of 40 miles per hour over the measured mile course.

During the World War Mr. Seabury was consulting marine engineer with the Foundation Company at Savannah and New Orleans. Since 1919 he was engaged as a consulting naval architect.

Mr. Seabury became a member of the Society in 1894. He died April 7, 1922.

URIEL SEBREE

ASSOCIATE

Rear Admiral Sebree was born in Fayette, Mo., on February 20, 1848, the son of John P. and Louisa Dailey Sebree. He obtained his early education in the schools of Fayette.

On July 23, 1863, he was appointed a midshipman at the U. S. Naval Academy, Annapolis, Md., from the Eighth Missouri District and graduated in June, 1867.

His subsequent service in the Navy was of a very varied character but, due to the stagnation in promotion, resulting from the decrease in officer personnel after the conclusion of the Civil War, he was one of that large and distinguished group of officers who spent a substantial part of their active career in the grade of Lieutenant, not being promoted to the grade of Lieutenant Commander until March 26, 1889. His subsequent promotions were Commander, February 24, 1897; Captain, October 9, 1901; Rear Admiral, July 8, 1907.

Although compelled to spend so large a portion of his active service in grades below that of Commander, his great ability and marked enthusiasm for his profession caused him to be assigned to many very important duties, among the most noteworthy of which were those in connection with Arctic Expeditions,—notably, the Arctic Relief Expedition on the U. S. S. Tigress in 1873, under Commander Greer; and the Greely Relief Expedition of 1884, under Commander Schley.

He was the first Executive Officer of the U. S. S. Baltimore, one of the earliest vessels of our so-called new steel Navy, and served as Executive Officer of that vessel under Captain Schley, his old commanding officer on the U. S. S. Thetis during the Greely Relief Expedition.

Among other assignments to duty prior to attaining flag rank were two tours of duty at the U. S. Naval Academy; duty as Lighthouse Inspector and Secretary of the Lighthouse Board; member of the Board of Inspection and Survey; and sea service in command of various coast-survey vessels, the U. S. S. Wheeling of the Bering Sea Patrol, the U. S. Battleship Wisconsin; also duty as Chief of Staff of the cruiser squadron, and duty as Governor of the Samoan Islands.

After reaching flag rank he was assigned to duty as Commander of the Second Division of the Pacific Fleet from 1907-9, and in 1909-10 he served as Commander-in-Chief of the Pacific Fleet.

Admiral Sebree was an officer of the highest type and always had not only the confidence and highest esteem of his seniors, but the very genuine affection of his colleagues, both juniors and seniors. On no duty were his manly and officer-like qualities more highly appreciated than as an instructor at the Naval Academy, where his influence for good in moulding the character of the midshipmen with whom he came in direct contact was especially notable.

He was particularly interested in everything connected with his profession, and this in-

terest included not only personnel, ordnance, navigation and seamanship, but it extended to the material, including all matters connected with the development of shipbuilding. He was a Charter Associate Member of the Society of Naval Architects and Marine Engineers and maintained his interest in its work, as well as his membership, until his death.

He retired from active service on February 20, 1910, after a notable active career in the Navy, twenty-two years and eleven months of which were spent at sea.

Admiral Sebree died at his home in Coronado, California, on August 6, 1922. He is survived by his widow, the daughter of the late Colonel Bridgman, U. S. Army, whom he married in 1886; also by one son, Captain John Bridgman Sebree, U. S. Marine Corps.

JOHN SHIELDS

MEMBER

Mr. Shields was born in Newry, Ireland, January 1, 1850.

He was educated in the schools of Newry and Belfast, after which he served an apprenticeship as machinist in the mills at Bessbrook, Ireland. He then went to Liverpool, where he was in the employ of the well-known shop of "Jacks."

After coming to this country he was engaged in the shops of the Worthington Pump Works, Brooklyn, following which he became associated with Handren & Robins, which company was later absorbed by the John N. Robins Company. Mr. Shields remained with the John N. Robins Company for twenty-five years until 1898 when he, together with Frank Mulhearn and John A. Moran, formed a partnership known as the Atlantic Basin Iron Works, which was finally incorporated in December, 1902. Mr. Shields became president of the Atlantic Basin Iron Works at the time of incorporation and served in that capacity until his death, November 1, 1921.

He became a member of the Society of Naval Architects and Marine Engineers in 1913.

FRANK WALKER

MEMBER

Mr. Walker was born in Kings Lynn, Norfolk, England, May 7, 1867. His father was engaged in the manufacture of agricultural machinery, and in the shops of his father he gained a mechanical foundation that was rounded out in an apprenticeship in one of the great English shipyards. During this apprenticeship be attended the South Kensington evening schools, graduating with high honors. Completing his apprenticeship, he turned to the sea, where he rapidly rose from junior engineer, and at the age of 21 held a first grade chief engineer's license. In 1896 he took up his abode in Tacoma, Washington, becoming port engineer for Dodwell & Company and later superintendent of the Quartermaster Harbor Drydocks. During the Klondike gold rush he designed and had built several vessels for lake service in the north. In 1907 Mr. Walker took up his residence in Seattle, where he engaged in marine surveying and naval architecture and as time progressed obtained the

agency for a number of eastern concerns engaged in manufacturing marine auxiliaries and equipment.

During the World War Mr. Walker was representative of the French Government and in this capacity constructed a large number of vessels for that nation.

Although in declining health during the last few years of his life, Mr. Walker was actively engaged in business until the time of his death, September 29, 1922, and has to his credit the design and construction of many fine ships.

He leaves a widow and three sons, one of whom is a member of this Society and has been associated with his father for several years. A fourth son gave up his life at the battle-front during the late war in the service of the Australian Government.

PLATES

To illustrate paper on "Automatic Steering," by Elmer A. Sperry, E. D., Member.

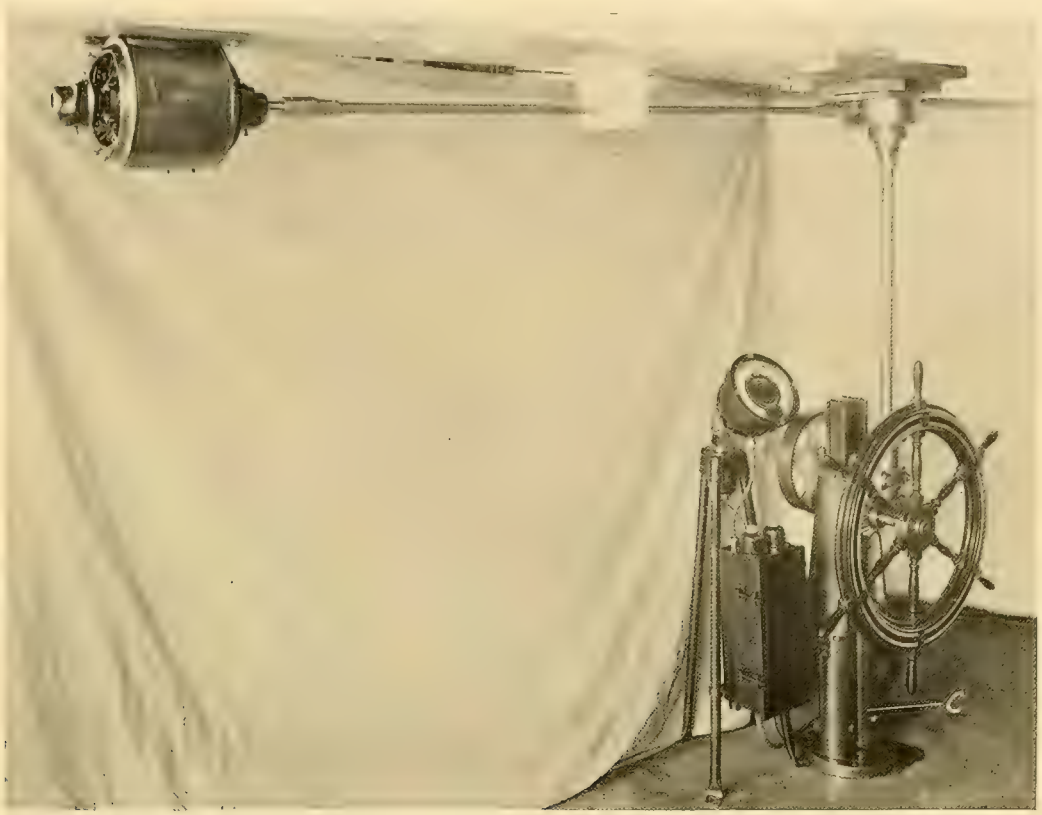


FIG. 1.—SEPARATE SYSTEM SHOWING THE STEERING MOTOR OVERHEAD, DETACHABLY CONNECTED TO THE STEERING WHEEL AUTOMATIC MECHANISM IN THE ENCLOSURE UNDER THE SPECIAL GYRO REPEATER.

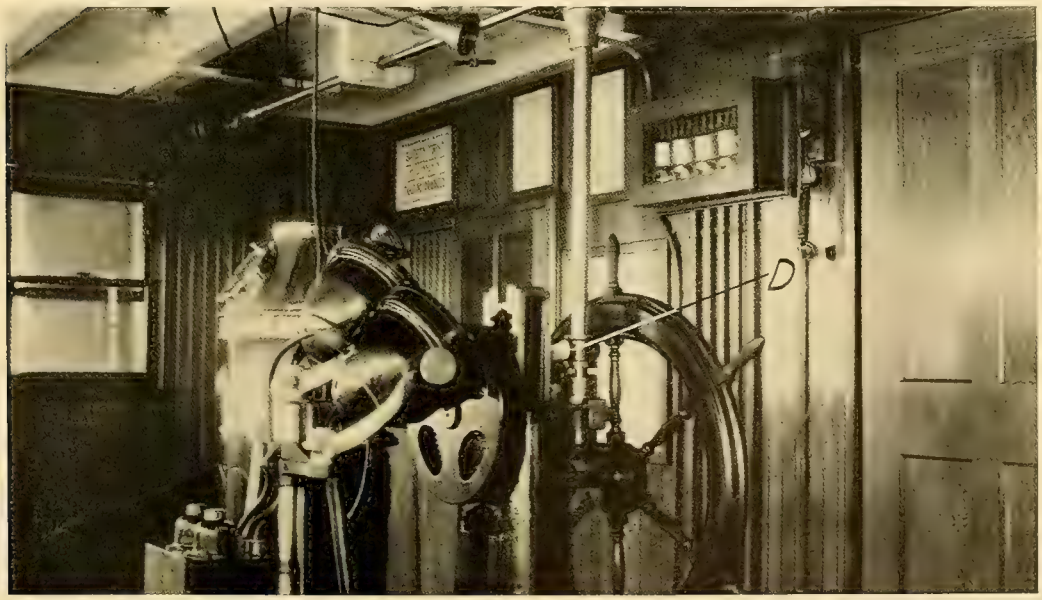


FIG. 2.—SAME TYPE WITH THE ADDITION OF THE HELMSMAN GYRO REPEATER ON TANKER JOHN D. ARCHBOLD, THE DISCONNECTING CLUTCH AND PART OF ITS OPERATING LEVER SEEN AT *D*

To illustrate paper on "Automatic Steering," by Elmer A. Sperry, E. D., Member.

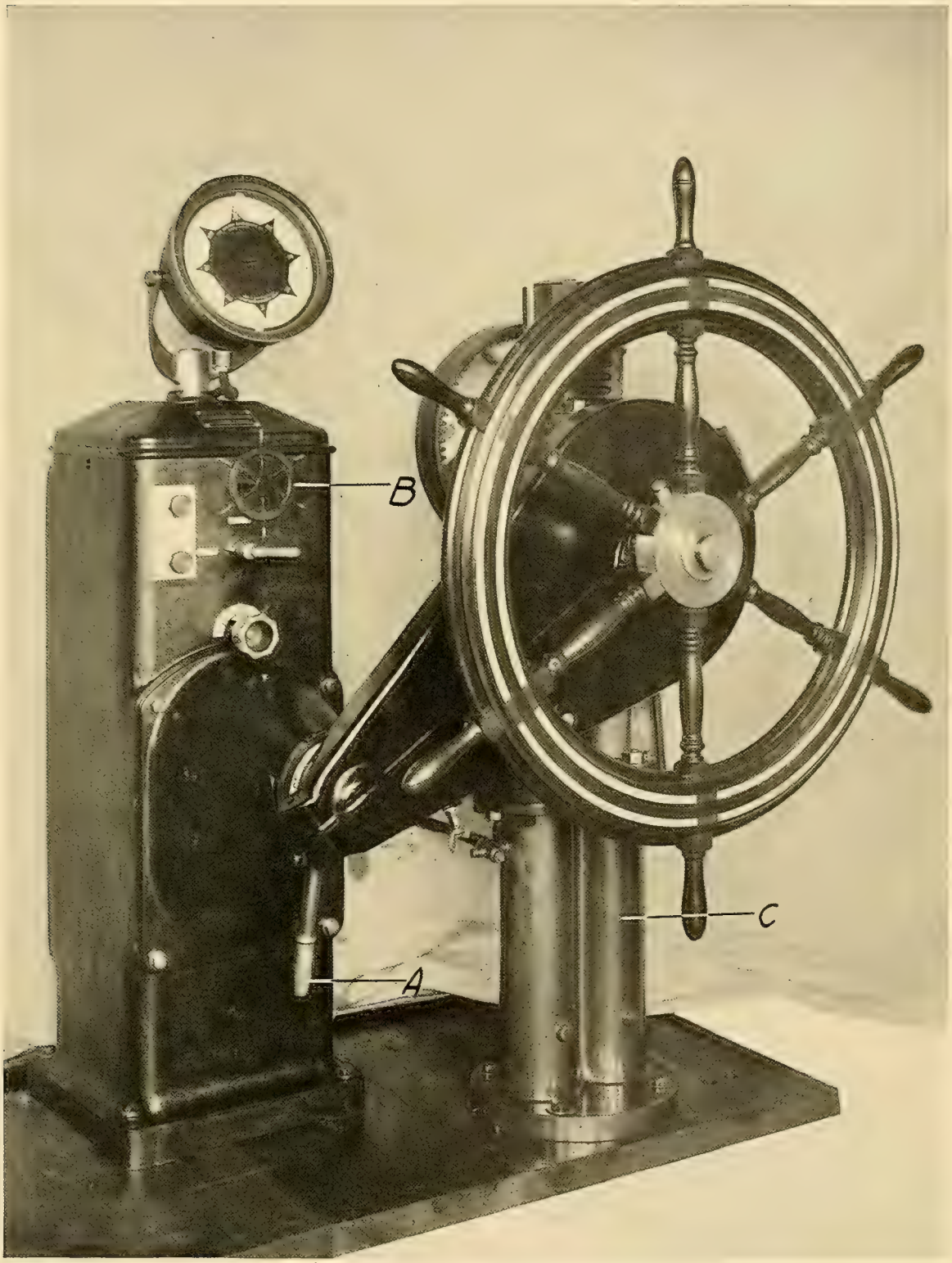
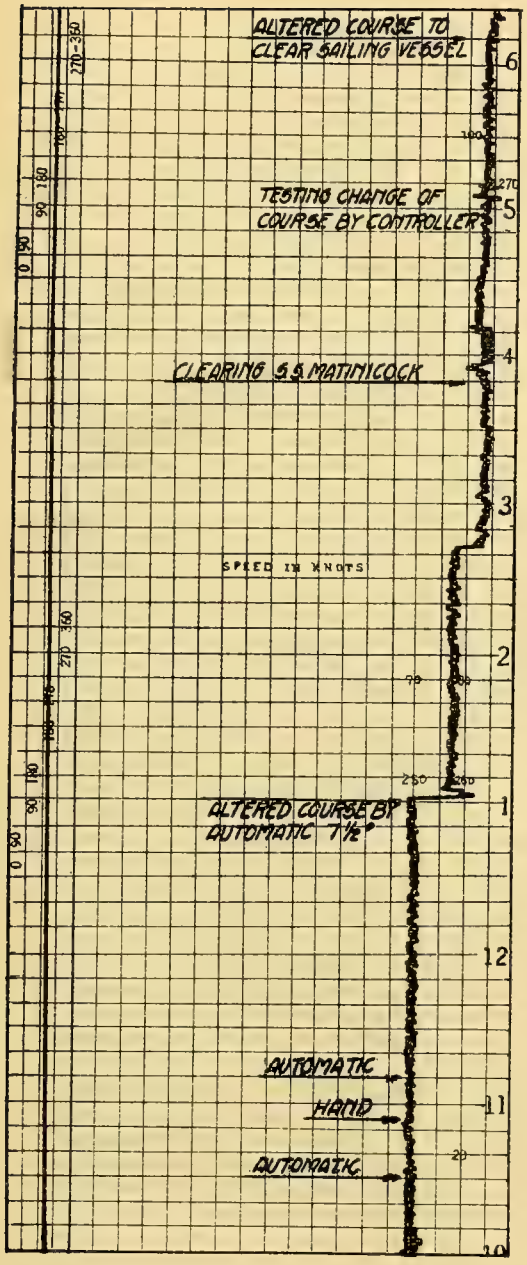
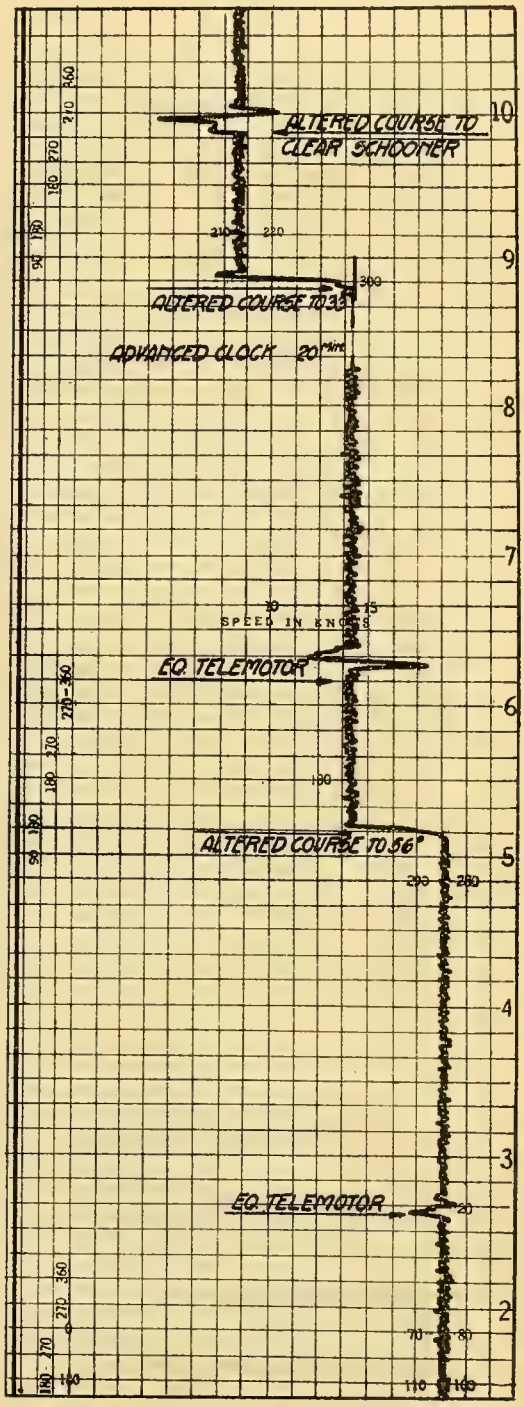


FIG. 3.—UNIT SYSTEM STANDING NEAR THE STEERING WHEEL AND TELEMOTOR *C*, *A* THE HANDLE FOR THROWING ON AND OFF, *B* LITTLE TILLER WHEEL FOR SETTING COURSE AND STEERING SHIP THROUGH AUTOMATIC.

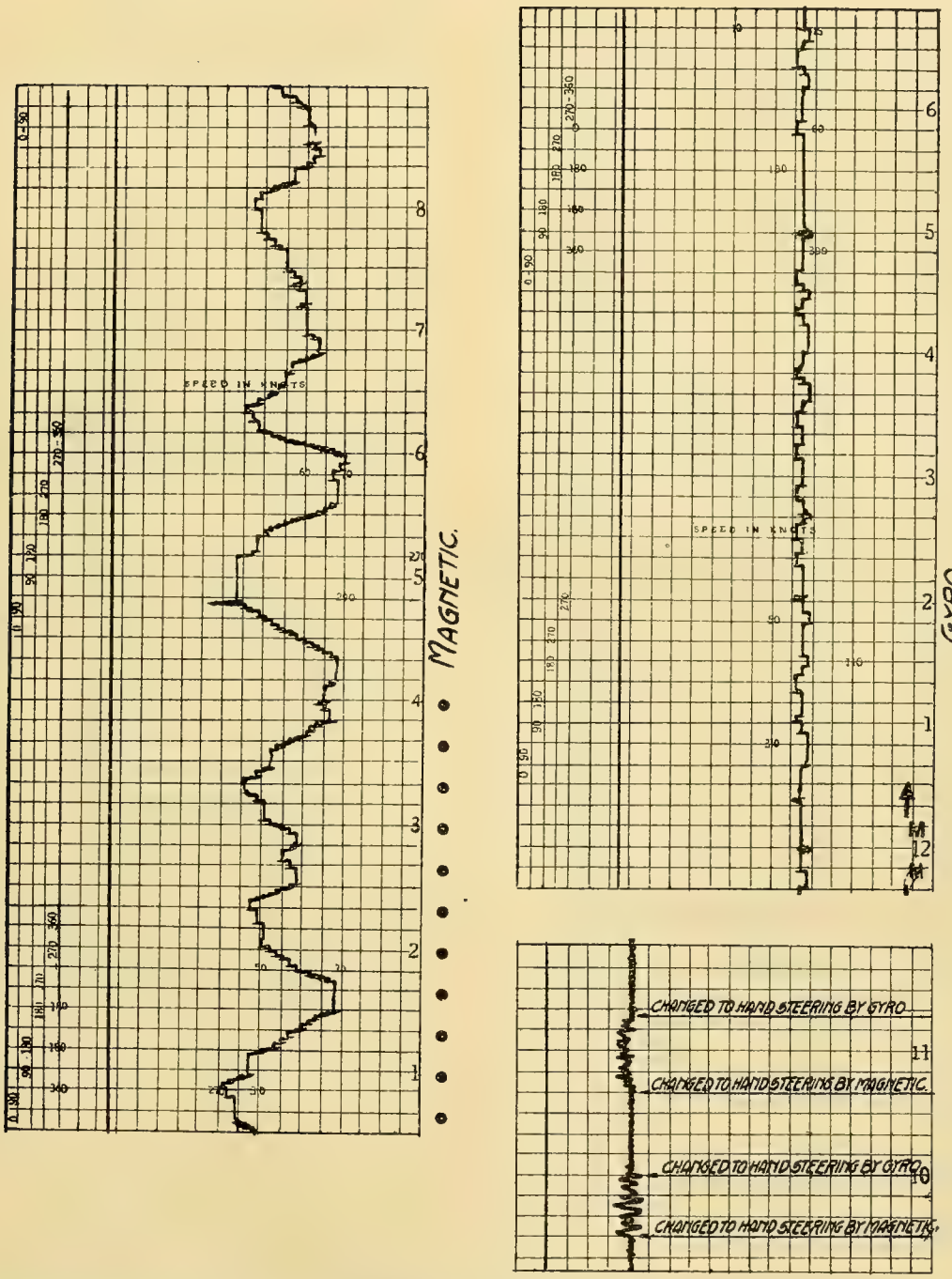
To illustrate paper on "Automatic Steering," by Elmer A. Sperry, E. D., Member.





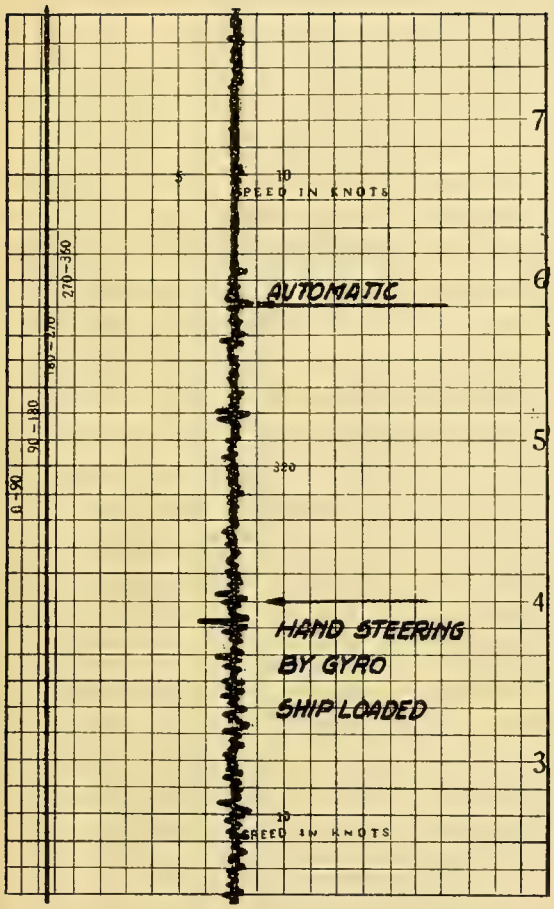
Figs. 4 and 5. - Records of automatic steering of the tanker John D. Archbold, the curve at right being loaded, displacement about 32,000 tons, the curve at left, while light or in ballast, displacement about 12,000 tons.

To illustrate paper on "Automatic Steering," by Elmer A. Sperry, E. D., Member.


MAGNETIC.
GYRO
CHANGED TO HAND STEERING BY GYRO
CHANGED TO HAND STEERING BY MAGNETIC.
CHANGED TO HAND STEERING BY GYRO
CHANGED TO HAND STEERING BY MAGNETIC.
Fig. 6

Figs. 6 and 7.-Group of records showing the difference between steering by magnetic and by gyro by the same helmsman, Fig. 6 being a small part on natural scale, Fig. 7 being parts of a similar record on a scale magnified ten times. The instantaneous action of the gyro compass and the complete absence of lag make possible the marked difference apparent.

To illustrate paper on "Automatic Steering," by Elmer A. Sperry, E. D., Member.



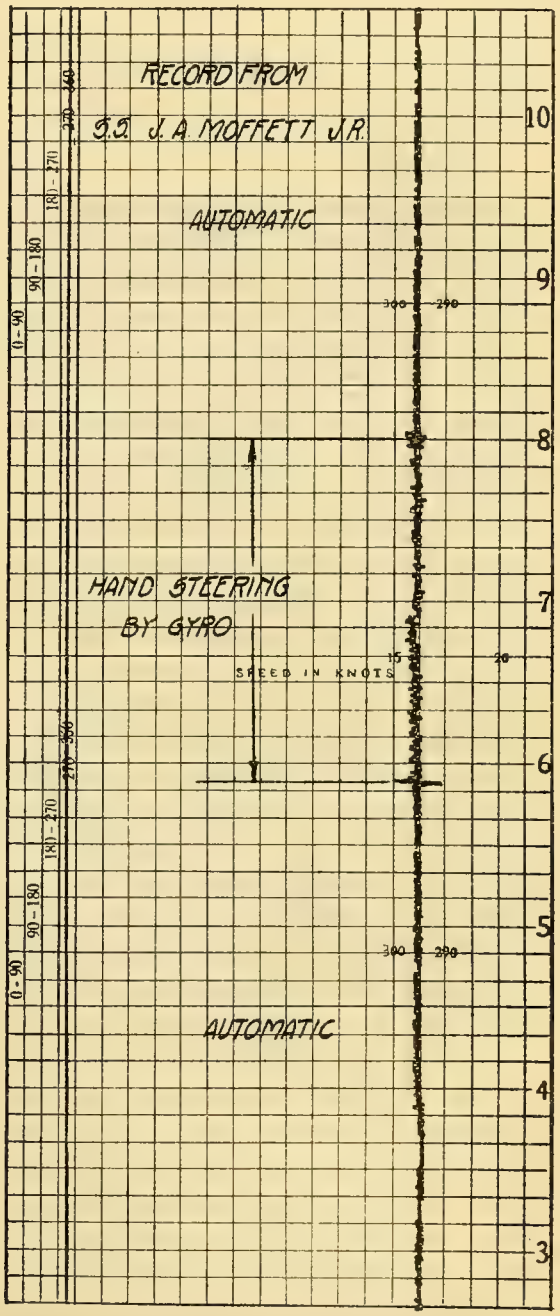
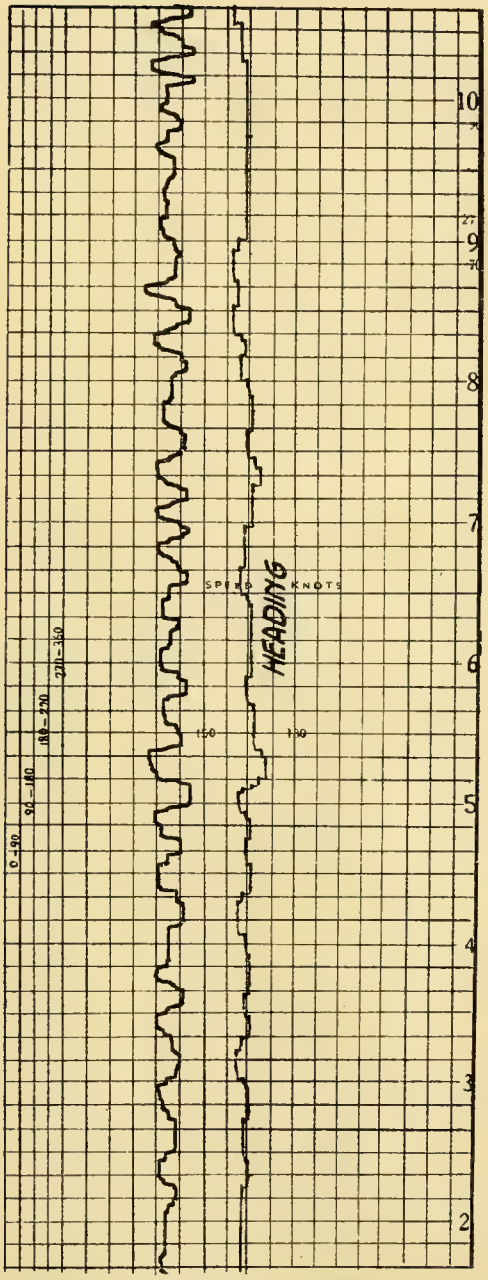


Fig. 8 and Fig. 8 A - Automatic steering compared with high-class hand steering with different quarter-masters.

To illustrate paper on "Automatic Steering," by Elmer A. Sperry, E. D., Member.



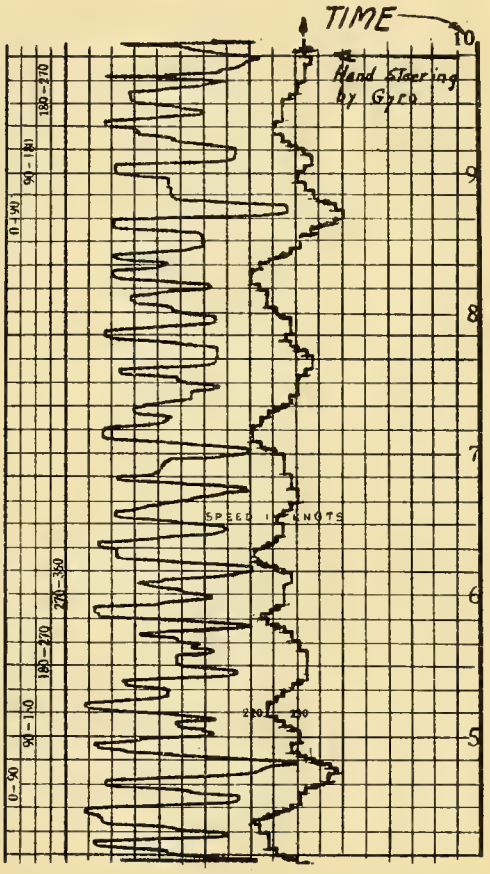


Fig. 9. - Simultaneous record of ship's heading and helm angle by specially magnified quick moving reel for studying effects of different helm angles and anticipation. Each step in all magnified records of heading equals one sixth of a degree.

Fig. 10. -Simultaneous record of ship's heading and helm angle when steering with magnetic compass, portraying graphically the power-consuming factors in constantly applying large helm angles with best steering possible by magnetic.

To illustrate paper on "Automatic Steering," by Elmer A. Sperry, E. D., Member.

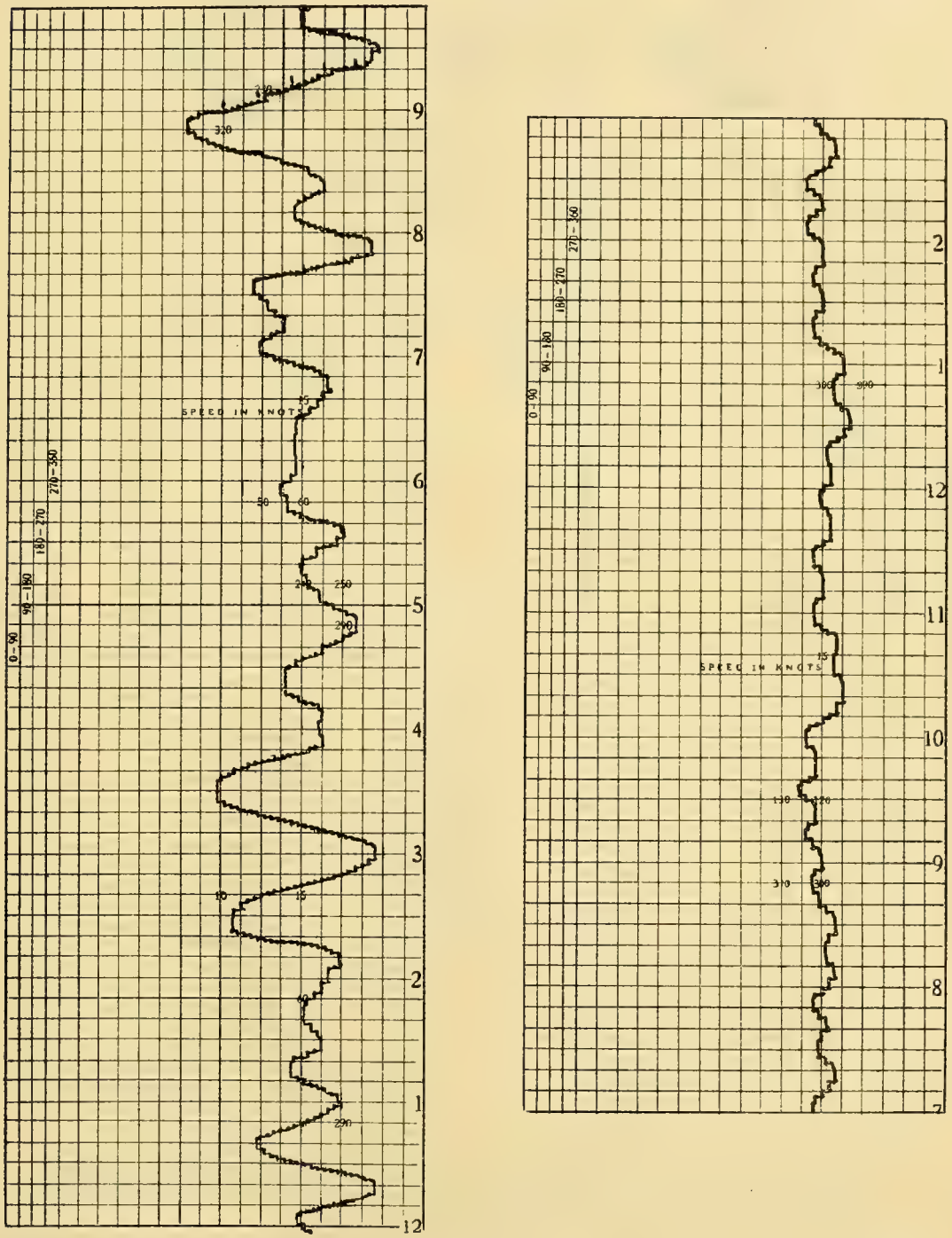
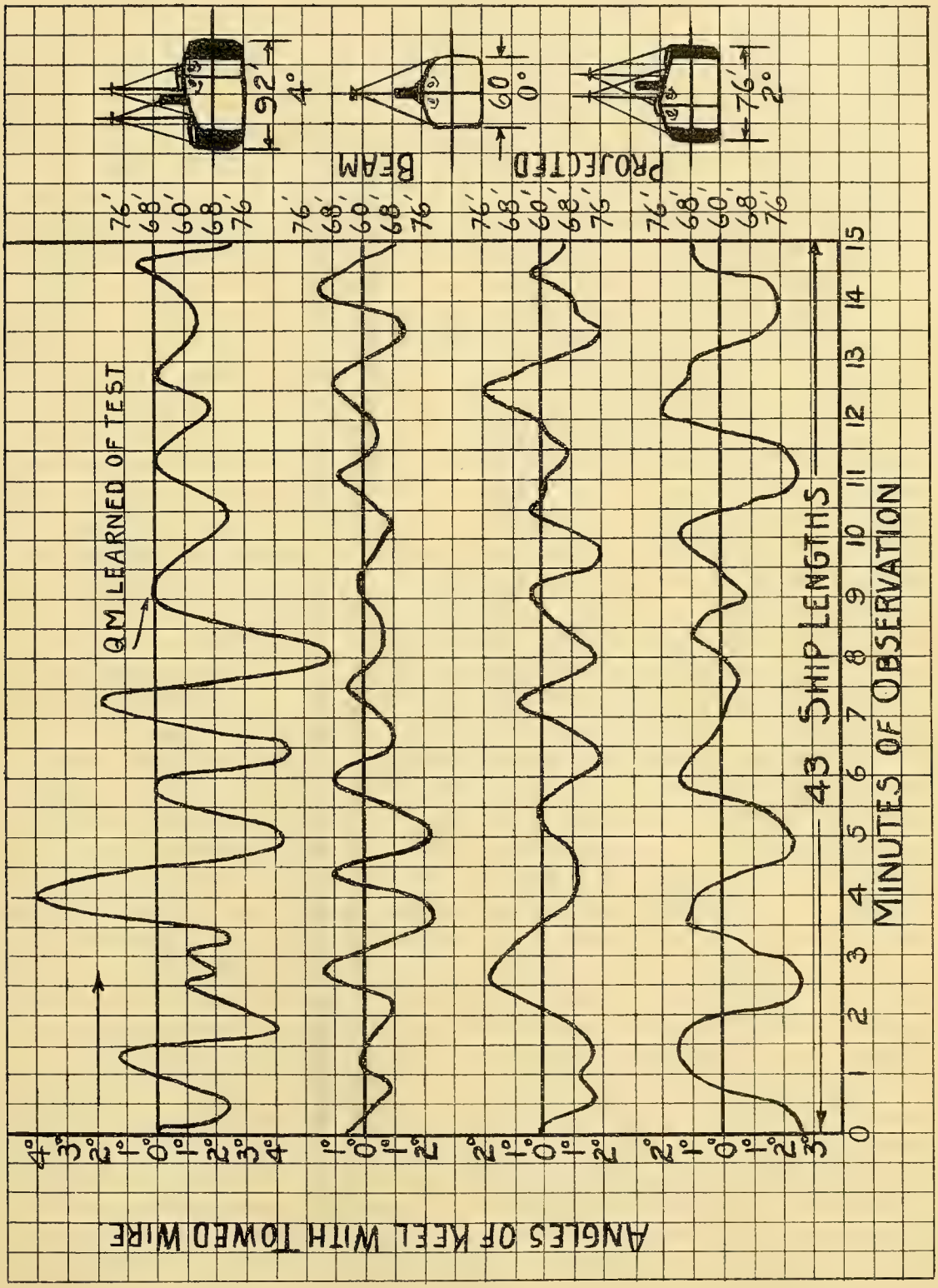


Fig. 11. - Steering by hand and by automatic in heavy weather, the chart at right immediately following the one at left, same scale. Note the automatic holds the ship very closely on her course, averaging less than one half of a degree either side.

To illustrate discussion by Robert H. Rogers, Esq., Visitor, on paper entitled "Automatic Steering," by Elmer A. Sperry, E. D., Member.



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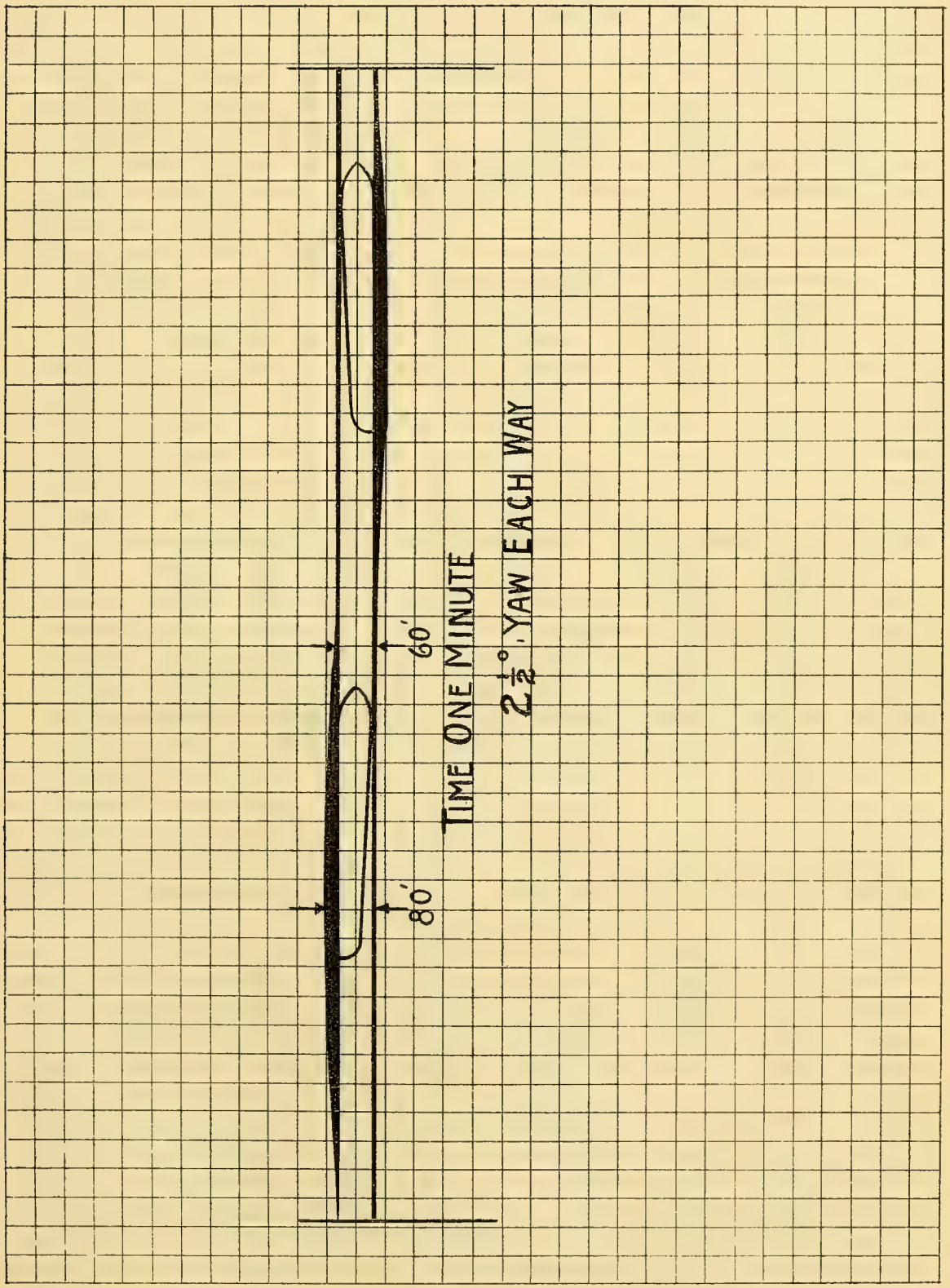

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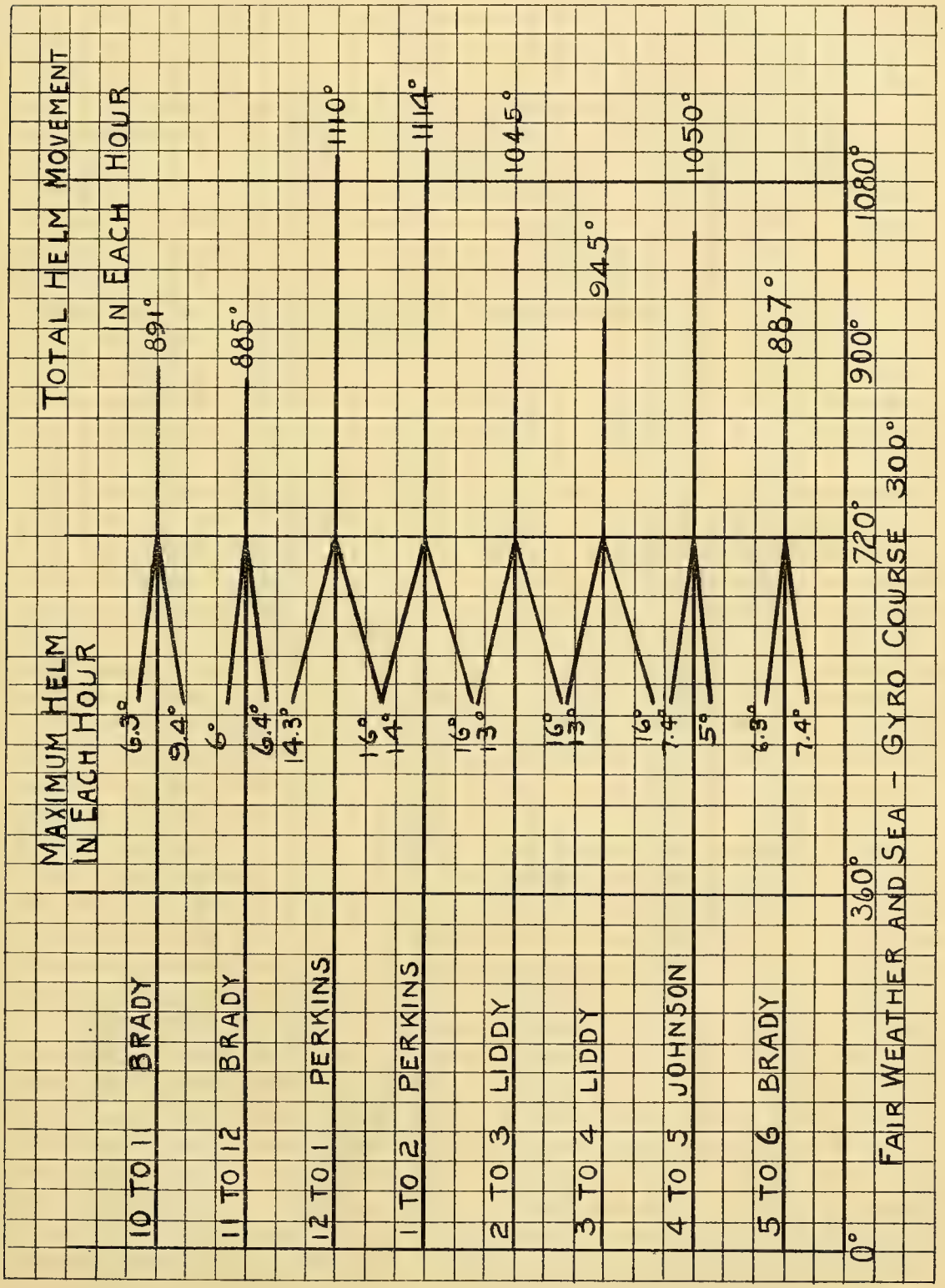

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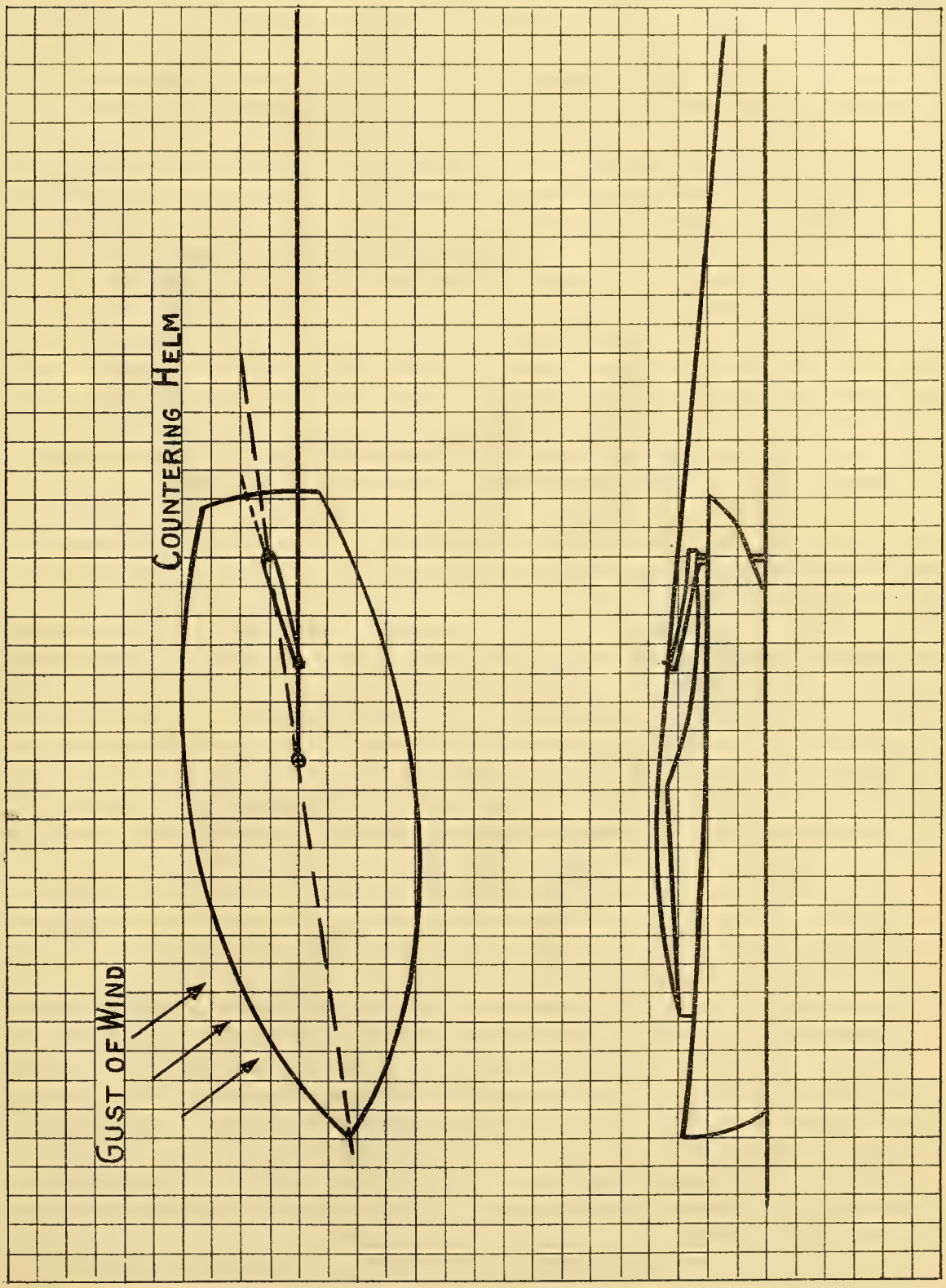

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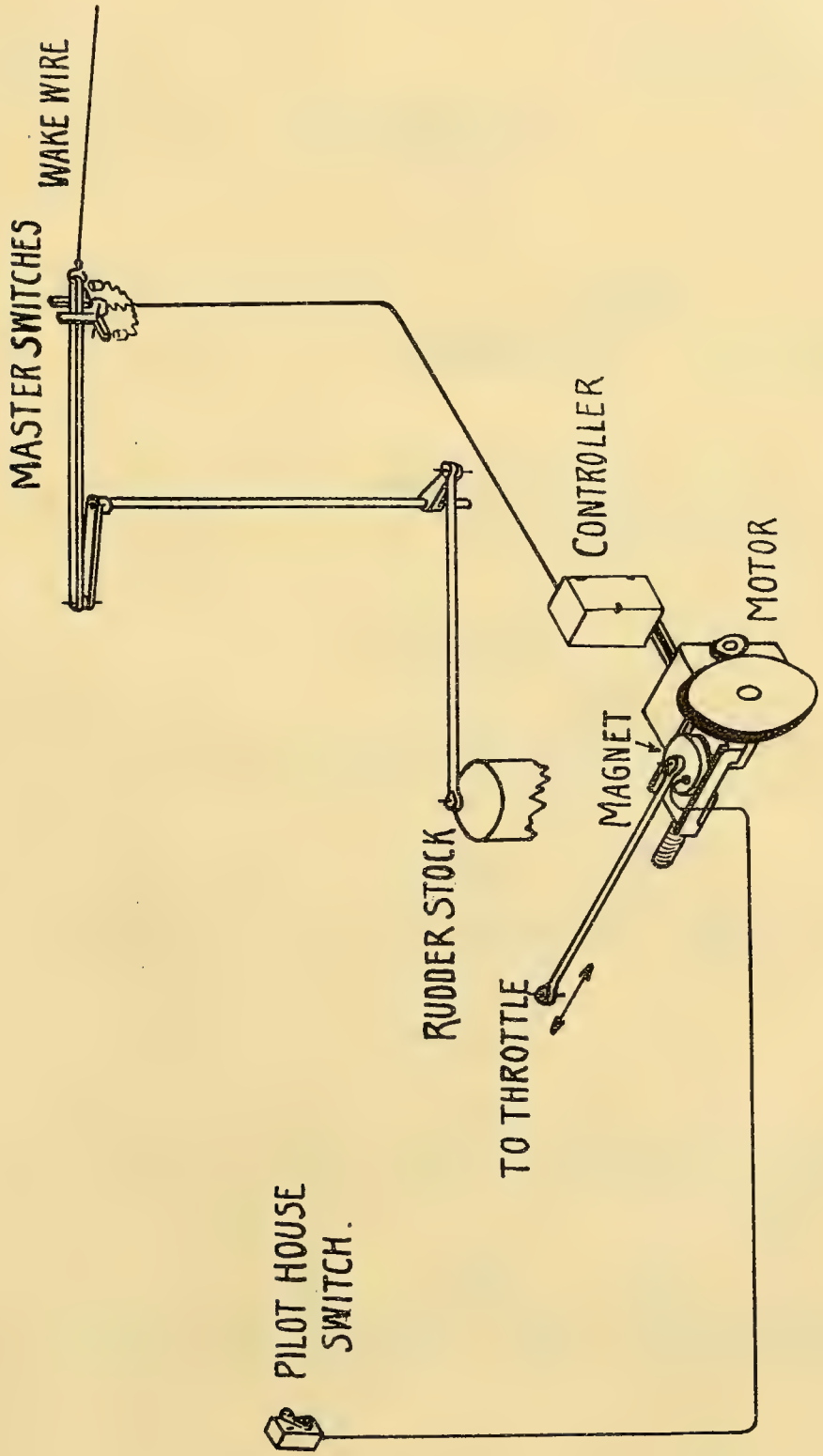
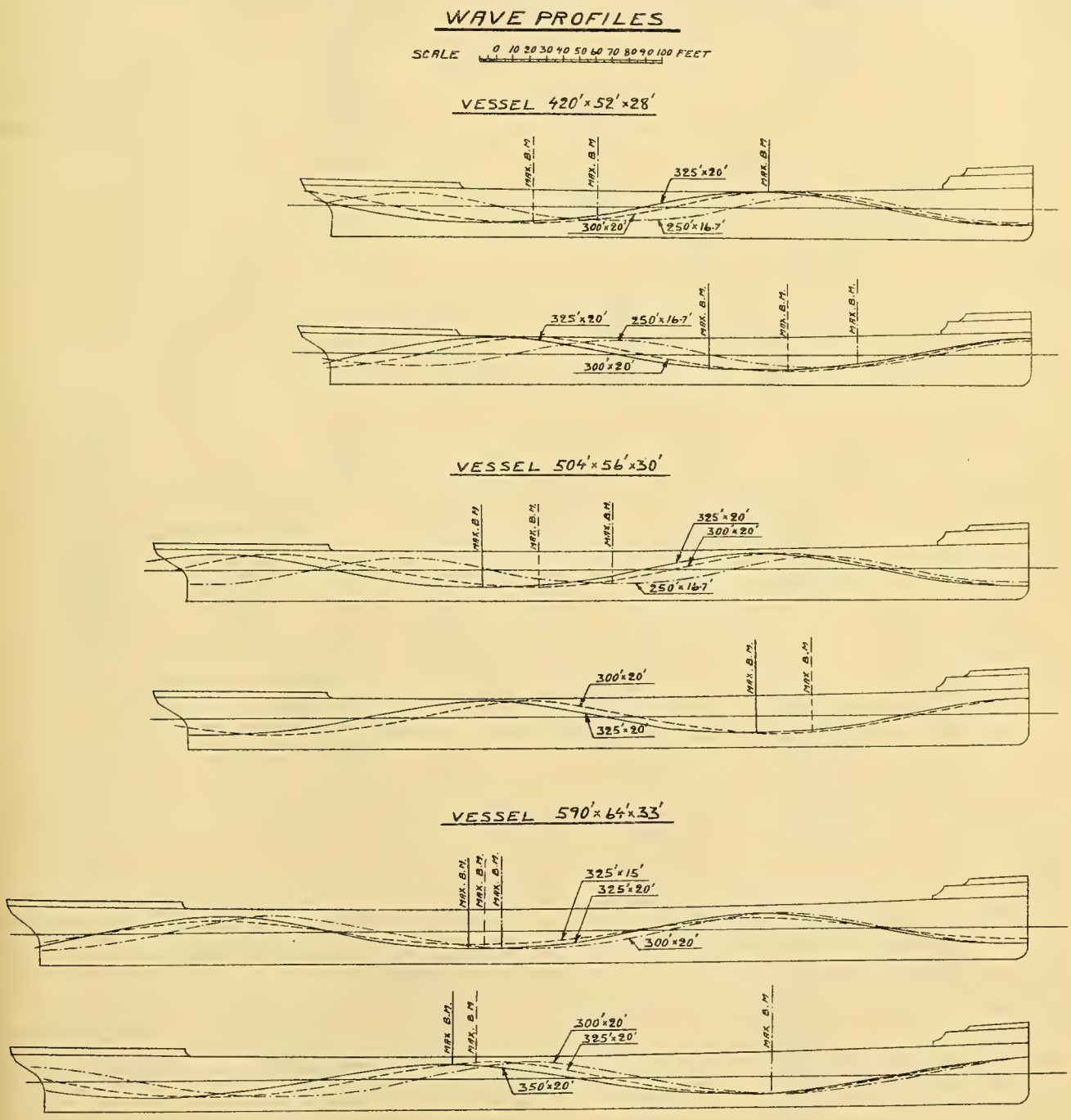


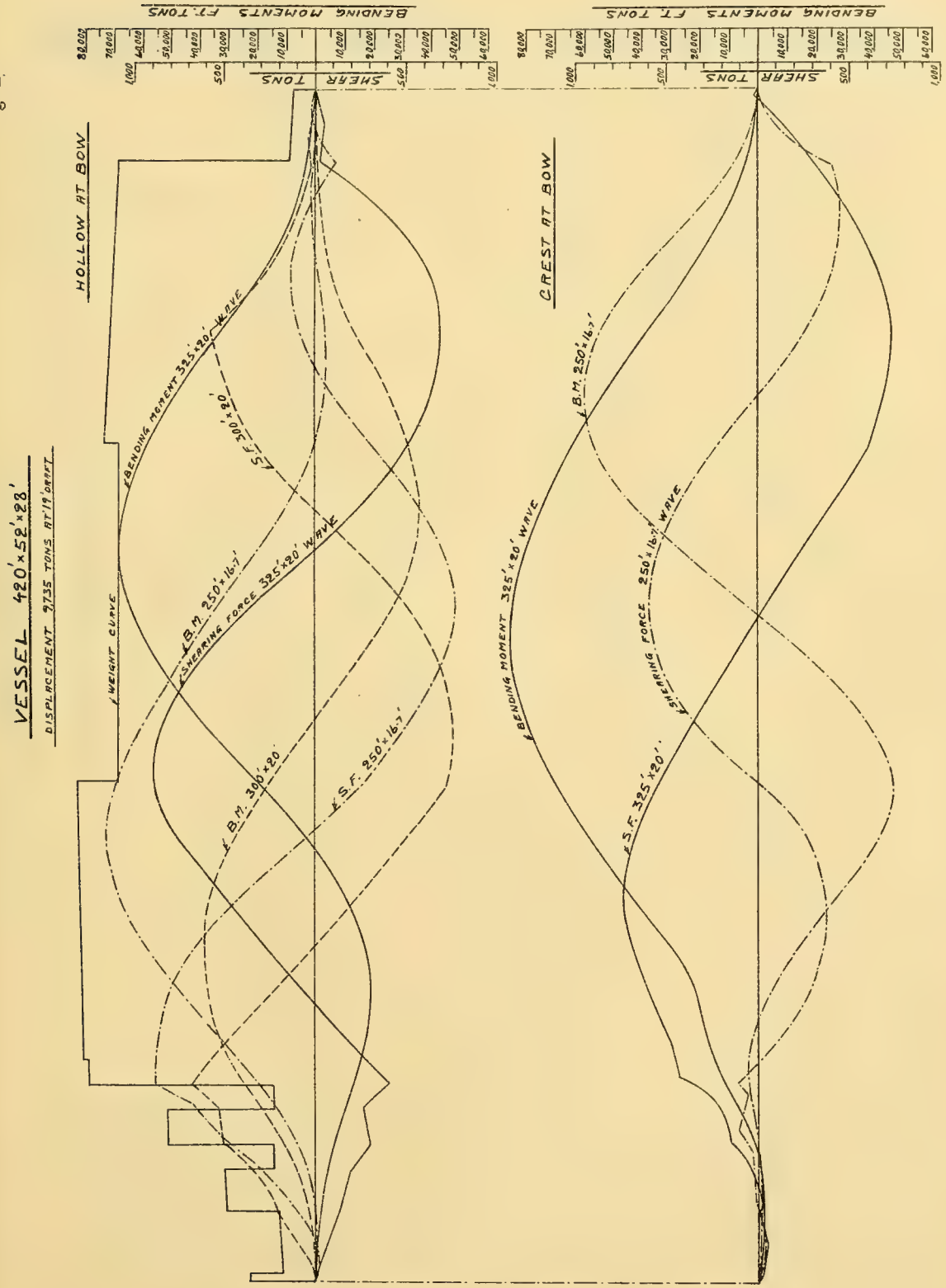
To illustrate paper on "Stresses on Vessels of the Great Lakes Due to Waves of Varying Lengths and Heights," by Professor Herbert C. Sadler, Member of Council, and Professor A. Lindblad, Member.

Fig I



To illustrate paper on "Stresses on Vessels of the Great Lakes Due to Waves of Varying Lengths and Heights," by Professor Herbert C. Sadler, Member of Council, and Professor A. Lindblad, Member.

Fig. 2.



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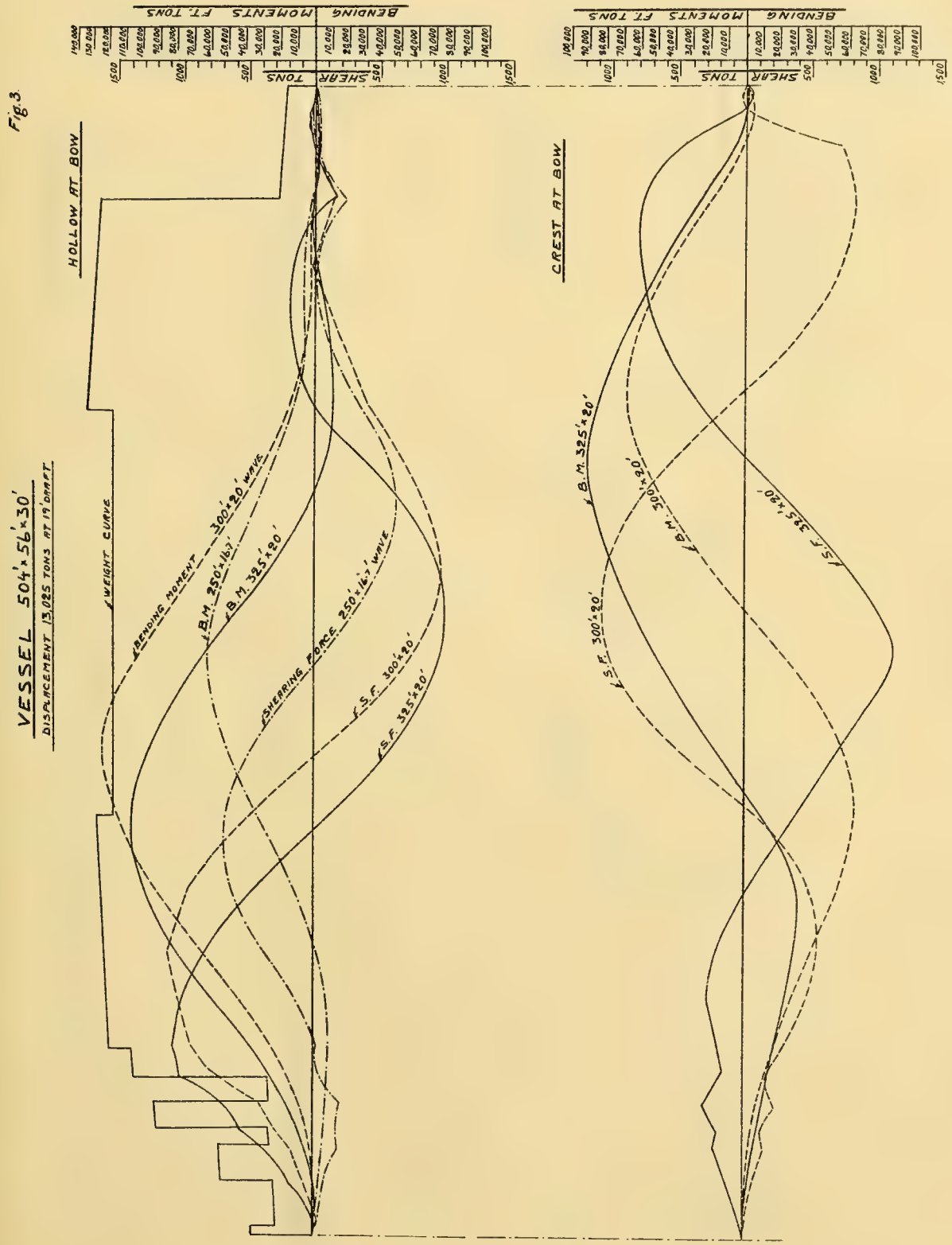

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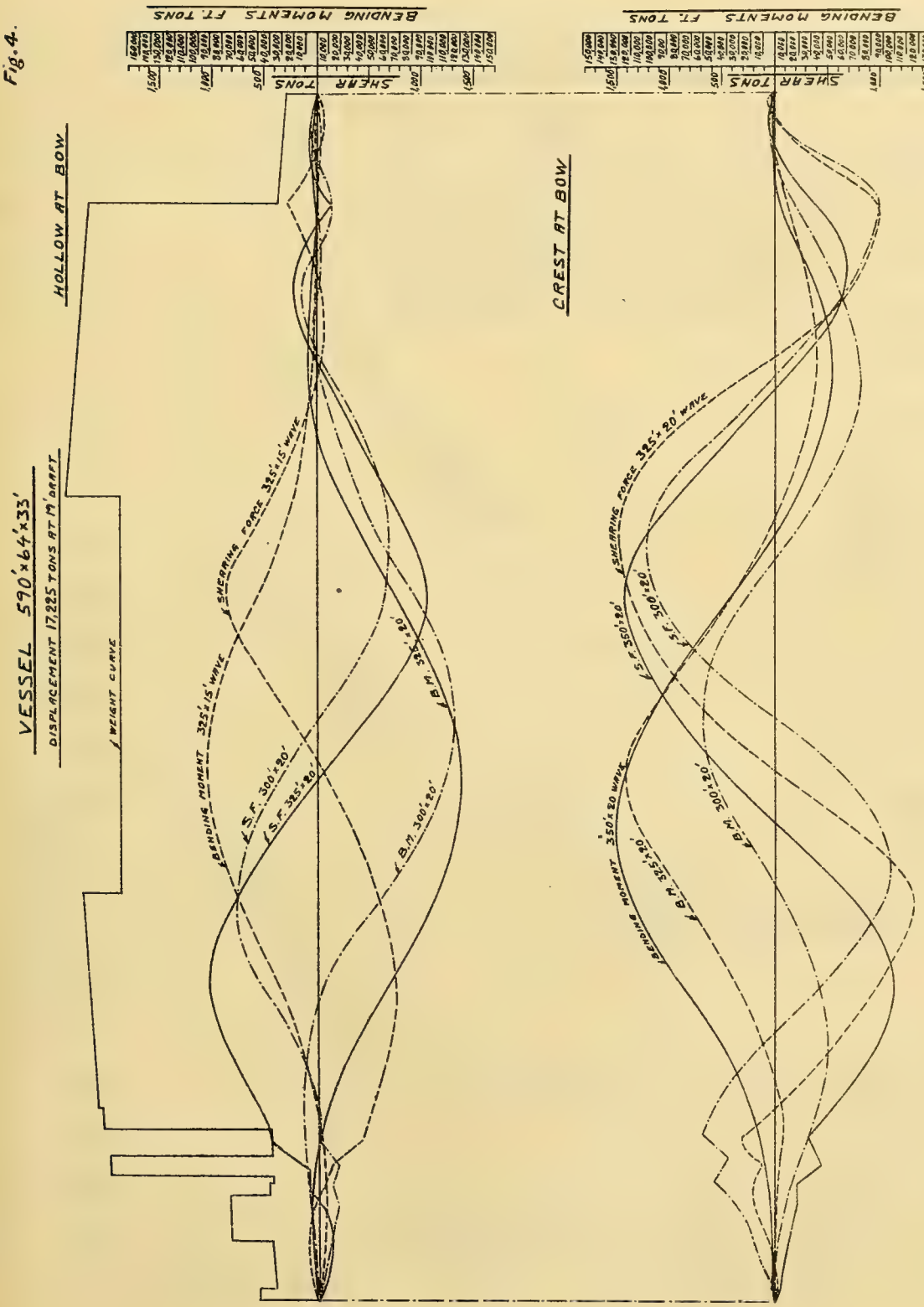
Fig. 4.



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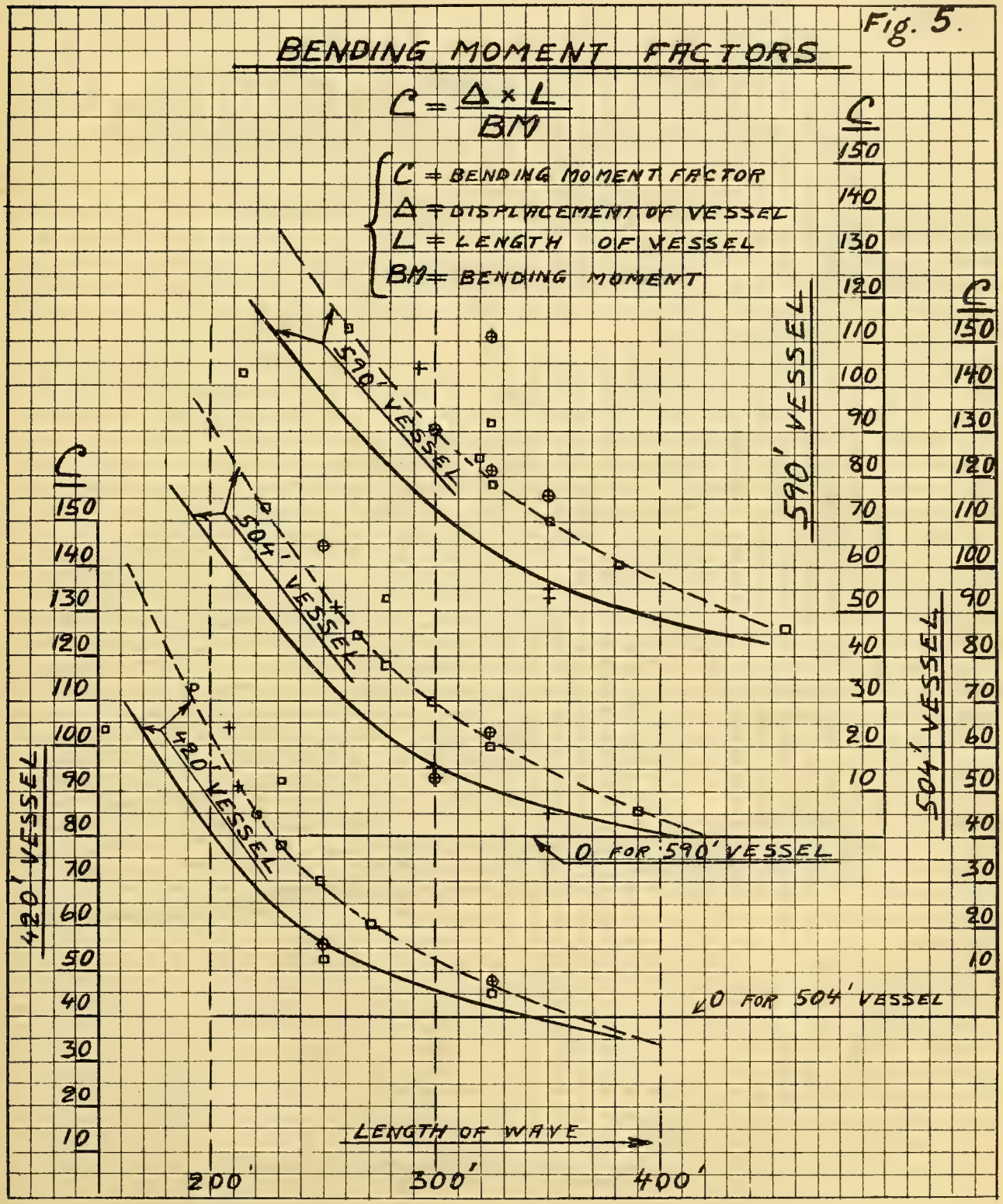

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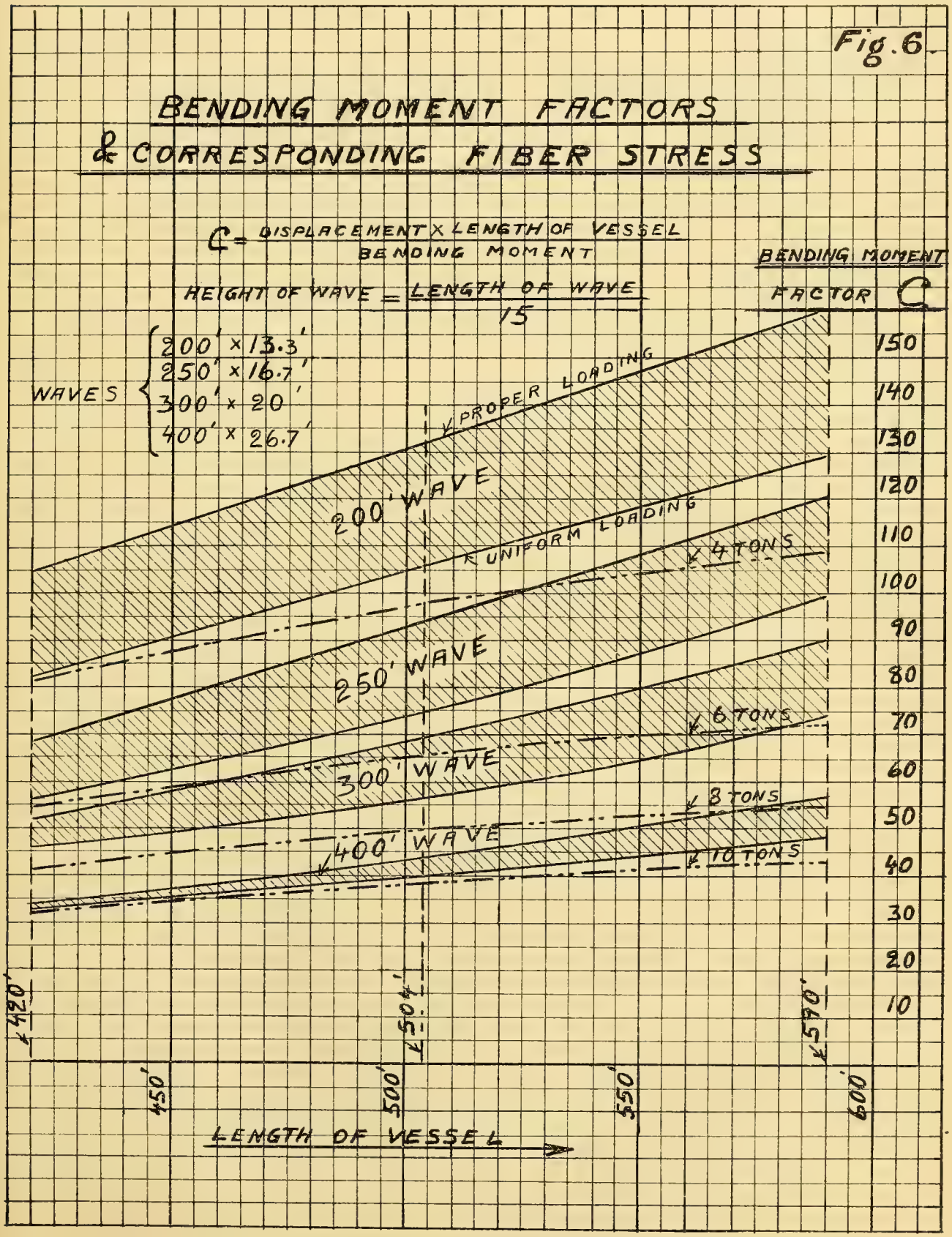

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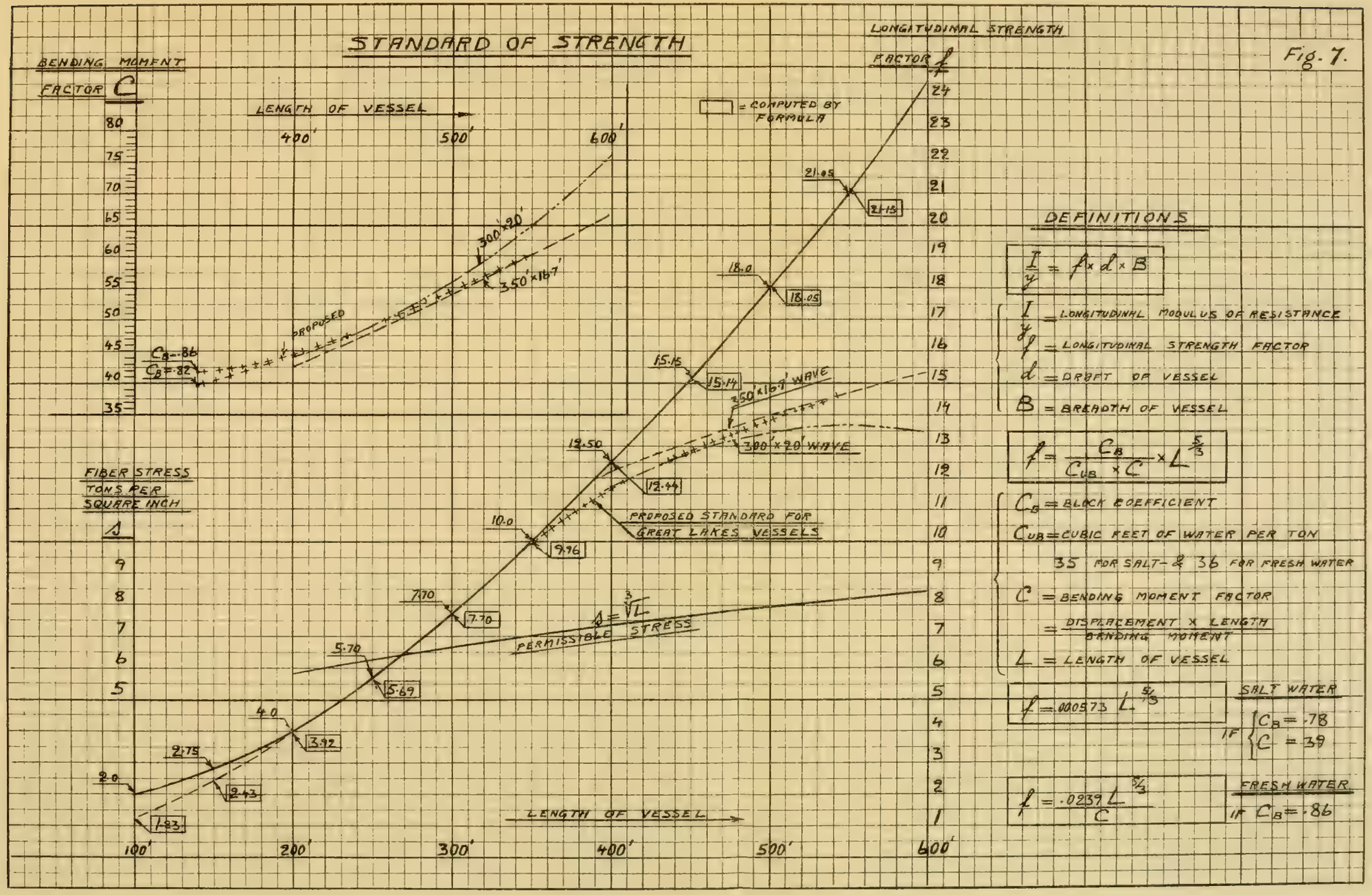


To illustrate paper on "The Application of Dyson's Method to Propellers of Ocean Going Vessels," by E. A. Stevens, Jr., Esq., Member.

PROBLEM No 1

Hull			Propeller		
L = LWL or LBP	=	419.25	No of Propellers	=	1
B = Beam	=	56.25	No of Blades	=	4
H = Draught	=	25.562	Diam = D.	=	18
Δ = Displacement Fresh Water	=	13390	Pitch = P	=	15.5
Nominal Block Coeff	=	.801	PA ÷ DA	=	.35
M. S. Coeff	=	.98	¾ x PA ÷ DA	=	.2625
H ÷ B	=	.455	T. S	=	6150
Type	=	2	P x R	=	1685
B ÷ L	=	.134	I - S	=	.86
B.C. on line C-D	=	.688	V	=	14.3
B.C. on line C-D corrected for $\frac{H}{B}$	=	.75	I.T$_d$	=	2.97
Slip B.C. line Z	=	.845	I.H.P.	=	64.25
LAB	=	146.7	P. C	=	.652
2 LAB ÷ H	=	11.5	E.H.P.	=	1490
S = Basic Slip	=	.14	S.H.P.	=	
K. B.C.	=	.804			
K	=	1.28			

v	11.5	11	10.5	10	9	8
e.h.p.	1523	1315	1130	973	718	507
e.h.p ÷ E.H.P.	.364	.314	.27	.232	.171	.121
10^{2p}	2.87	3.34	3.92	4.57	6.29	.902
I.H.P$_d$	2865	2460	2100	1800	1310	912
Actual I.H.P$_d$.	2724	2392	2090	1835	1355	975
$v \div V$	.805	.77	.735	.70	.63	.56
10^{2s}	1.54	1.76	2.00	2.31	3.13	4.38
S	.096	.094	.092	.091	.089	.087
R_d	83.3	79.4	75.6	72	64.6	57.4
Actual R_d	79.7	76.3	73	69.9	63	56.2

PROBLEM No 2

Hull			Propeller		
L = LWL or LBP	=	385	No of Propellers	=	1
B = Beam	=	51	No of Blades	=	4
H = Draught	=	26	Diam = D.	=	17.5
Δ = Displacement	=	11590	Pitch = P	=	19
Nominal Block Coeff	=	.793	PA ÷ DA	=	.36
M. S. Coeff	=	.989	¾ x PA ÷ DA	=	.27
H ÷ B	=	.51	T. S	=	6290
Type	=	2	P x R	=	2170
B ÷ L	=	.1325	I - S	=	.86
B.C. on line C-D	=	.676	V	=	18.4
B.C. on line C-D corrected for $\frac{H}{B}$	=	.805	I.T$_d$	=	3.12
Slip B.C. line Z	=	.882	I.H.P.	=	8220
LAB	=	145	P. C	=	.646
2 LAB ÷ H	=	11.15	E.H.P.	=	5310
S = Basic Slip	=	.14	S.H.P.	=	
K. B.C.	=	.795			
K	=	1.255			

v	11.192
I.H.P$_d$ on trial	2.695
$v \div V$	.608
10^{2s}	3.412
S	.152
R_d	70.4
R_d on trial	69.75
e.h.p$_1$ ÷ E.H.P.	.302
10^{2p_1}	3.48
$10^{2p_2} = \sqrt{\frac{I.H.P_d \times 10^{2s}}{I.H.P_{d_1}}}$	3.257
$10^{2p} = 10^{2p_2} \times K$	4.07
e.h.p. ÷ E.H.P.	.26
e.h.p. = E.H.P. x $\frac{e.h.p.}{E.H.P.}$	1380
Estimated e.h.p.	1385

To illustrate paper on "The Application of Dyson's Method to Propellers of Ocean Going Vessels," by E. A. Stevens, Jr., Esq., Member.

PROBLEM No 3

Hull			Propeller		
L = LW.L. or LBP	=	390	No of Propellers	=	1
B = Beam	=	54	No of Blades	=	4
H = Draught	=	24.5	Diam = D.	=	17
Δ = Displacement	=	11450	Pitch = P	=	14.03
Nominal Block Coeff	=	.776	PA ÷ DA	=	.374
M. S. Coeff	=	.996	¾ x PA ÷ DA	=	.27
H ÷ B	=	.454	T. S	=	6290
Type	=	2	P x R	=	1650
B ÷ L	=	.1385	1 - S	=	.833
B.C. on line C-D	=	.668	V	=	13.56
B.C. on line C-D corrected for H/B	=	.73	I.T$_d$.	=	3.12
Slip B.C. line Z	=	.833	I.H.P.	=	5890
L A B	=	136	P. C	=	.637
2 L A B ÷ H	=	11.1	E.H.P.	=	3755
S = Basic Slip	=	.167	S.H.P.	=	5420
K. B.C.	=	.79			
K	=	1.24			

V	11.38
e.h.p.	1350
e.h.p. ÷ E.H.P.	.36
10^{2P}	2.9
S.H.P$_d$.	2320
S.H.P$_d$. Estimated	2500
v ÷ V	.84
10^{2S}	1.37
s	.098
R_d	89.3
Actual R_d	88.8.

PROBLEM No 4

Hull			Propeller		
L = LW.L. or LBP	=	410.16	No of Propellers	=	1
B = Beam	=	54	No of Blades	=	4
H = Draught	=	23.5	Diam = D.	=	17.083
Δ = Displacement	=	11989	Pitch = P	=	16.02
Nominal Block Coeff	=	.80	PA ÷ DA	=	.382
M. S. Coeff	=	.985	¾ x PA ÷ DA	=	.286
H ÷ B	=	.435	T. S	=	6540
Type	=	2	P x R	=	1950
B ÷ L	=	.1315	1 - S	=	.792
B.C. on line C-D	=	.682	V	=	15.25
B.C. on line C-D corrected for H/B	=	.715	I.T$_d$.	=	3.44
Slip B.C. line Z	=	.823	I.H.P.	=	7760
L A B	=	123	P. C	=	.632
2 L A B ÷ H	=	10.45	E.H.P.	=	4900
S = Basic Slip	=	.208	S.H.P.	=	
K. B.C.	=	.80			
K	=	1.27			

v	11.16
e.h.p.	1480
e.h.p. ÷ E.H.P.	.302
10^{2P}	3.48
I.H.P$_d$.	2930
Actual I.H.P$_d$.	2774
v ÷ V	.732
10^{2S}	2.02
s	.153
R_d	83.8
Actual R_d	83.1

To illustrate paper on "The Application of Dyson's Method to Propellers of Ocean Going Vessels," by E. A. Stevens, Jr., Esq., Member.

PROBLEM No 5

Hull			Propeller		
L = LW.L or L.B.P.	=	331	No of Propellers	=	1
B = Beam	=	47	No of Blades	=	4
H = Draught	=	16.92	Diam = D.	=	14.5
Δ = Displacement	=	4875	Pitch = P	=	14.5
Nominal Block Coeff	=	.65	PA ÷ DA	=	.40
M. S. Coeff	=	.954	¾ x PA ÷ DA	=	.30
H ÷ B	=	.36	T.S	=	6766
Type	=	2	P x R	=	2150
B ÷ L	=	.142	I - S	=	.947
BC on line C-D	=	.565	V	=	20.3
BC on line C-D corrected for H/B	=	.49	I.T$_d$	=	3.73
Slip BC line Z	=	.65	I.H.P.	=	6680
LAB	=	142.75	P.C	=	.62
2 LAB ÷ H	=	16.85	E.H.P.	=	415
S = Basic Slip	=	.053	S.H.P.	=	
K.B.C.	=	.712			
K	=	1.102			

V	12.792	12.233	11.246	9.876	7.839
e.hp	1110	935	730	505	260
e.hp ÷ EHP	.258	.225	.176	.1218	.0627
10^{2p}	4.10	4.72	6.07	9.0	17.89
IHP$_{d1}$	1000	1560	1215	819	412
Actual IHP$_d$	1750	1604	1123	798	431
V ÷ V	.63	.604	.555	.486	.386
10^{2s}	3.13	3.535	4.49	6.585	12.66
s	.045	.044	.043	.043	.042
R$_d$	93.6	89.4	82.0	72.1	57.1
Actual R$_d$	95.38	92.85	82.97	74.82	56.34

PROBLEM No 6

Hull			Propeller		
L = LW.L or LBP	=	410.46	No of Propellers	=	1
B = Beam	=	54	No of Blades	=	4
H = Draught	=	24.167	Diam = D.	=	17.00
Δ = Displacement	=	12250	Pitch = P	=	15.75
Nominal Block Coeff	=	.80	PA ÷ DA	=	.342
M. S. Coeff	=	.982	¾ x PA ÷ DA	=	.2565
H ÷ B	=	.447	T.S	=	6070
Type	=	2	P x R	=	1790
B ÷ L	=	.1314	I - S	=	.785
BC on line C-D	=	.677	V	=	13.87
BC on line C-D corrected for H/B	=	.73	I.T$_d$	=	2.86
Slip BC line Z	=	.833	I.H.P	=	5860
LAB	=	123	P.C	=	.6575
2 LAB ÷ H	=	10.2	E.H.P.	=	3850
S = Basic Slip	=	.215	S P	=	
K.B.C	=	.796			
K	=	1.26			

V	9.385	8.952	7.007	5.615
Actual IHP$_d$	2088	1700	914	561.5
v ÷ V	.676	.645	.505	.405
10^{2s}	2.56	2.92	5.88	11.00
s	.196	.182	.197	.227
R$_d$	75.0	70.5	56.2	46.7
Actual R$_d$	74.57	70.38	55.98	46.83
e.hp$_1$ ÷ E.H.P.	.318	.27	.131	.08
10^{2_1}	3.30	3.92	8.35	13.98
$10^{2_{pg}} = \sqrt{\frac{IHP \times 10^{2_1}}{IHP_d}}$	3.04	3.675	7.32	12.08
$10^{2_p} = 10^{2_{pg}} \times K$	3.83	4.63	9.23	15.22
e.hp ÷ E.H.P.	.2755	.229	.118	.073
e.hp. = EHP. x (ehp ÷ EHP)	1060	882	455	281
e.hp Model 1013	898	787	406	220

To illustrate paper on "The Application of Dyson's Method to Propellers of Ocean Going Vessels," by E. A. Stevens, Jr., Esq., Member.

PROBLEM No 7

Hull			Propeller		
L = LWL or LBP	=	415	No of Propellers	=	1
B = Beam	=	56	No of Blades	=	4
H = Draught	=	25.5	Diam = D.	=	17.75
Δ = Displacement	=	13573	Pitch = P	=	17.5
Nominal Block Coeff	=	.806	PA ÷ DA	=	.375
M. S. Coeff	=	.973	¾ x PA ÷ DA	=	.281
H ÷ B	=	.455	T.S	=	6450
Type	=	2	P x R	=	2025
B ÷ L	=	.135	I - S	=	.87
BC on line C-D	=	.694	V	=	17.4
BC on line C-D corrected for H/B	=	.76	I.Ta	=	3.32
Slip BC line Z	=	.853	I.H.P	=	8400
LAB	=	148	P.C	=	.637
2 LAB ÷ H	=	11.6	E.H.P	=	5350
S = Basic Slip	=	.13	S.H.P	=	
K.B.C.	=	.808			
K	=	1.29			

v	11.322	10.934	11.375	10.868	11.405	9.905
v ÷ V	.652	.629	.654	.625	.656	.57
10^{2s}	2.832	3.144	2.804	3.20	2.778	4.17
Actual I.H.P$_d$	2706	2601	2756	2510	2886	1997
s	.119	.127	.120	.124	.124	.127
R$_d$	74.4	72.5	74.6	71.6	75.3	65.8
Actual R$_d$	75.2	72.46	74.2	71.55	74.07	64.85
$10^{2p} = \frac{IHP \times K}{IHP_d}$	4.00	4.16	3.935	4.31	3.755	5.425
ehp ÷ EHP	.264	.2545	.2685	.246	.281	.197
ehp = EHP x (ehp ÷ EHP)	1423	1362	1437	1317	1504	1053
Estimated ehp	1450	1280	1480	1260	1490	940

PROBLEM No 8

Hull			Propeller		
L = LWL or LBP	=	520	No. of Propellers	=	2
B = Beam	=	65.23	No of Blades	=	3
H = Draught	=	27.75	Diam = D.	=	15.954
Δ = Displacement	=	19452	Pitch = P	=	14.422
Nominal Block Coeff	=	.725	PA ÷ DA	=	.304
M. S. Coeff	=	.984	~~x EA ÷ DA~~	=	
H ÷ B	=	.425	T.S	=	6850
Type	=	2	P x R	=	1972
B ÷ L	=	.125	I - S	=	.805
BC on line C-D	=	.593	V	=	15.67
BC on line C-D corrected for H/B	=	.60	I.Ta	=	3.8
Slip BC line X	=	.625	I.H.P	=	13100
LAB Estimated	=	183	P.C	=	.678
2 LAB ÷ H	=	13.2	E.H.P	=	8870
S = Basic Slip	=	.195	S.H.P	=	12050
K.B.C.	=	.618			
K	=	1.2			

v	14.99	14.00
e.h.p.	4420	3550
e.h.p. ÷ E.H.P	.498	.40
10^{2p}	2.06	2.59
S.H.P$_d$	7030	6580
Actual S.H.P$_d$	7150	5460
v ÷ V	.957	.894
10^{2s}	1.0	1.134
s	.114	.102
R$_d$	118.8	109.5
Actual R$_d$	116.72	108.5

To illustrate paper on "The Application of Dyson's Method to Propellers of Ocean Going Vessels," by E. A. Stevens, Jr., Esq., Member.

PROBLEM No 9

Hull			Propeller		
L = LW.L or LBP	=	520	No of Propellers	=	2.
B = Beam	=	62.23	No of Blades	=	3
H = Draught	=	27.35	Diam = D.	=	16.5
Δ = Displacement	=	18700	Pitch = P	=	18
Nominal Block Coeff	=	.726	PA ÷ DA	=	.278
M.S. Coeff	=	.984	~~n PA ÷ DA~~	=	
H ÷ B	=	.44	T.S	=	6410
Type	=	2	P x R	=	2225
B ÷ L	=	.118	1 - S	=	.92
BC on line C-D	=	.579	V	=	18.0
BC on line C-D corrected for $\frac{H}{B}$	=	.61	I.Td.	=	3.29
Slip BC line X	=	.635	I.H.P.	=	13680
LAB	=	184	P.C	=	.691
2 LAB ÷ H	=	13.45	E.H.P.	=	9450
S = Basic Slip	=	.18	S.H.P.	=	
K.B.C.	=	.605			
K	=	1.188			

v	15.5
e.h.p.	5130
e.h.p ÷ E.H.P.	.543
10^{2p}	1.886
I.H.Pd	8620
Actual I.H.Pd	8400
v ÷ V	.862
10^{2s}	1.278
s	.145
Rd	102
Actual Rd	98.2

PROBLEM No 10

Hull			Propeller		
L = LW.L or LBP	=	522	No of Propellers	=	2
B = Beam	=	62	No of Blades	=	3
H = Draught	=	19.4	Diam = D.	=	16.5
Δ = Displacement	=	12.000	Pitch = P	=	16.167
Nominal Block Coeff	=	.671	PA ÷ DA	=	30
M.S. Coeff	=	.992	~~n PA ÷ DA~~	=	
H ÷ B	=	.313	T.S	=	6766
Type	=	2	P x R	=	2107
B ÷ L	=	.119	1 - S	=	.834
BC on line C-D	=	.533	V	=	17.33
BC on line C-D corrected for $\frac{H}{B}$	=	.42	I.Td.	=	3.73
Slip BC line X	=	.455	I.H.P.	=	14680
LAB	=	208	P.C	=	.68
2 LAB ÷ H	=	21.5	E.H.P.	=	10000
S = Basic Slip	=	.166	S.H.P.	=	
K.B.C.	=	.562			
K	=	1.145			

v	14.79
e.h.p	3700
e.h.p ÷ E.H.P	.37
10^{2p}	2.82
I.H.Pd	5960
I.H.Pd on trial Estimated	6540
v ÷ V	.854
10^{2s}	1.305
s	.088
Rd	101.8
Actual Rd	104.75

To illustrate paper on "The Application of Dyson's Method to Propellers of Ocean Going Vessels," by E. A. Stevens, Jr., Esq., Member.

PROBLEM No 11

Hull			Propeller		
L = LW.L or L.B.P	=	530	No of Propellers	=	2
B = Beam	=	72	No of Blades	=	3
H = Draught	=	24	Diam = D.	=	17.00
Δ = Displacement	=	16013	Pitch = P	=	18.50
Nominal Block Coeff	=	.612	PA ÷ DA	=	.315
M. S. Coeff	=	.982	~~x PA ÷ DA~~	=	
H ÷ B	=	.334	T. S	=	7020
Type	=	2	P x R	=	2430
B ÷ L	=	.136	I - S	=	.86
B.C. on line C-D	=	.526	V	=	20.60
B.C. on line C-D corrected for $\frac{H}{B}$	=	.451	$I.T_d$	=	4.02
Slip B.C. line X	=	.485	I.H.P.	=	19350
L A B	=	2.50	P. C	=	.673
2 L A B ÷ H	=	2.12	E.H.P.	=	13020
S = Basic Slip	=	.14	S.H.P.	=	17810
K. B.C.	=	.552			
K	=	1.12			

v	20	19	18	16	14	12
e.h.p.	9875	7950	6700	4700	3125	1950
e.h.p. ÷ E.H.P.	.758	.611	.515	.361	.2405	.1497
10^{2p}	1.335	1.67	1.994	2.89	4.415	7.22
$S.H.P_d$	14950	11950	10000	6900	4520	2760
Actual $S.H.P_d$	14950	11900	9855	6800	4525	2850
$v \div V$	.971	.922	.874	.777	.68	.582
10^{2s}	1.0	1.04	1.214	1.711	2.52	3.93
s	.118	.098	.095	.093	.089	.085
R_d	122.7	115.4	109	96.6	84.2	71.8
Actual R_d	122	115	109	96	83.5	71

PROBLEM No 11

Hull			Propeller		
L = LW.L or L.B.P	=	535	No of Propellers	=	2
B = Beam	=	72	No of Blades	=	3
H = Draught	=	30	Diam = D.	=	17.0
Δ = Displacement	=	20800	Pitch = P	=	18.5
Nominal Block Coeff	=	.63	PA ÷ DA	=	.315
M. S. Coeff	=	.987	~~x PA ÷ BA~~	=	
H ÷ B	=	.417	T. S	=	7020
Type	=	2	P x R	=	2430
B ÷ L	=	.1345	I - S	=	.855
B.C. on line C-D	=	.534	V	=	20.52
B.C. on line C-D corrected for $\frac{H}{B}$	=	.528	$I.T_d$	=	4.02
Slip B.C. line X	=	.558	I.H.P.	=	19350
L A B	=	265	P. C	=	.673
2 L A B ÷ H	=	17	E.H.P.	=	13020
S = Basic Slip	=	.145	S.H.P.	=	17810
K. B.C.	=	.563			
K	=	1.14			

v	19	18	16	14	12
e.h.p.	9475	8000	5600	3675	2275
e.h.p. ÷ E.H.P.	.728	.615	.43	.282	.1745
10^{2p}	1.393	1.659	2.405	3.74	6.16
$S.H.P_d$	14600	12250	8450	5430	3300
Actual $S.H.P_d$	14500	12100	8400	5500	3350
$v \div V$	.926	.8775	.78	.683	.585
10^{2s}	1.029	1.2	1.69	2.48	3.87
s	.122	.12	.116	.110	.104
R_d	118.7	112.2	99.2	86.1	73.3
Actual R_d	114.5	113	99.5	86.5	73.5

To illustrate paper on "The Application of Dyson's Method to Propellers of Ocean Going Vessels," by E. A. Stevens, Jr., Esq., Member.

PROBLEM No 11

Hull			Propeller		
L = LW.L. or LBP	=	535	No of Propellers	=	2
B = Beam	=	72	No of Blades	=	3
H = Draught	=	36	Diam = D.	=	17
Δ = Displacement	=	25863	Pitch = P	=	18.5
Nominal Block Coeff	=	.652	PA ÷ DA	=	.315
M. S. Coeff	=	.989	~~x PA ÷ DA~~	=	
H ÷ B	=	.5	T. S	=	7020
Type	=	2	P x R	=	2430
B ÷ L	=	.1345	1 - S	=	.867
B.C. on line C-D	=	.553	V	=	20.8
B.C. on line C-D corrected for $\frac{H}{B}$	=	.645	I.T$_a$.	=	4.02
Slip B.C. line X	=	.667	I.H.P.	=	19350
L A B	=	255	P. C	=	.673
2 L A B ÷ H	=	1417	E.H.P.	=	13020
S = Basic Slip	=	.133	S.H.P.	=	17810
K. B.C.	=	.576			
K	=	1.16			

v	19	18	16	14	12
e.h.p.	11200	9350	6375	4125	2550
e.h.p. ÷ EHP	.86	.718	.49	.317	.197
$10^{2.p}$	1.17	1.413	2.098	3.32	5.47
S.H.P$_d$.	17670	14620	9860	6230	3780
Actual SHP$_d$	17650	14700	10050	6500	4075
v ÷ V	.913	.865	.769	.673	.577
10^{2s}	1.066	1.25	1.766	2.59	4.02
s	.141	.137	.130	.121	.117
R$_d$	121.2	114.3	100.8	87.3	74.5
Actual R$_d$	124	117	103	89.5	76

PROBLEM No 11

Hull			Propeller		
L = LW.L. or LBP	=	530	No of Propellers	=	2
B = Beam	=	72	No of Blades	=	3
H = Draught	=	24	Diam = D.	=	16.5
Δ = Displacement	=	16013	Pitch = P	=	17.0
Nominal Block Coeff	=	.612	PA ÷ DA	=	.325
M. S. Coeff	=	.983	~~x PA ÷ DA~~	=	
H ÷ B	=	.334	T. S	=	7210
Type	=	2	P x R	=	2365
B ÷ L	=	.136	1 - S	=	.86
B.C. on line C-D	=	.526	V	=	20.05
B.C. on line C-D corrected for $\frac{H}{B}$	=	.451	I.T$_a$.	=	4.25
Slip B.C. line X	=	.485	I.H.P.	=	18750
L A B	=	250	P. C	=	.667
2 L A B ÷ H	=	2.1.2	E.H.P.	=	12500
S = Basic Slip	=	.14	S.H.P.	=	17250
K. B.C.	=	.552			
K	=	1.12			

v	19	18	16	14	12
e.h.p.	7950	6700	4700	3125	1950
e.h.p. ÷ EHP	.636	.536	.376	.25	.156
$10^{2.p}$	1.602	1.914	2.775	4.23	6.95
S.H.P$_d$.	12050	10080	6960	4570	2780
Actual S.H.P$_d$.	13400	11370	7820	5000	3120
v ÷ V	.948	.898	.798	.699	.599
10^{2s}	1.0	1.121	1.588	2.32	3.616
s	.098	.092	.09	.086	.081
R$_d$	125.5	118	104.7	91.3	77.8
Actual R$_d$	126.4	119.7	105.7	91	79

To illustrate paper on "The Application of Dyson's Method to Propellers of Ocean Going Vessels," by E. A. Stevens, Jr., Esq., Member.

PROBLEM No 12.

Hull			Propeller		
L = LW.L or LBP	=	663	No of Propellers	=	2
B = Beam	=	67	No of Blades	=	4
H = Draught	=	29	Diam = D.	=	22.32
Δ = Displacement	=	23300	Pitch = P	=	34.44
Nominal Block Coeff	=	.634	PA ÷ DA	=	.2625
M. S. Coeff	=	.943	¾ x PA ÷ DA	=	.197
H ÷ B	=	.433	T. S	=	5160
Type	=	2	P x R	=	2535
B ÷ L	=	.101	I - S	=	.933
B.C. on line C-D	=	.462	V	=	23.3
B.C. on line C-D Corrected for H/B	=	.47	I.T$_d$	=	1.8
Slip B.C. line Line X=.508 Y=.533	=	.519	I.H.P	=	18800
LAB	=	331	P. C	=	.697
2 LAB ÷ H	=	22.8	E.H.P	=	13100
S = Basic Slip	=	.067	S.H.P	=	
K.B.C. Line X=.496 Y=.526	=	.511			
K	=	1.10			

v	23.5	
Actual IHP	36000	
v ÷ V	1.008	
10^{2s}	1.90	
s	.128	
R_d	79.8	Estimated W.S = 61000 ft
Actual R_d	79.5	B ÷ H = 2.31 ; Pris Coeff .672
		Δ ÷ $(L_{WL}/100)^3$ = 80 ; v ÷ $\sqrt{L_{WL}}$ = .912
$10^{2p} = \frac{IHP \times K}{IHP_d}$	5.75	E_3 = .00307 x .009 x 61000 x 7588 = 12800
e.hp. ÷ E.H.P.	1.70	E_R = .00307 x 23300 x 5.4 x 23.5 = 9070
e.hp = E.H.P x e.hp/E.H.P	22300	e.hp Bare Hull = 21870
Estimated e.hp.	24057	e.hp. with App = 21870 x 1.1 = 24057

Note Draught on trial not known

PROBLEM No 13

Hull			Propeller		
L = LW.L or LBP	=	439.5	No of Propellers	=	2
B = Beam	=	60	No of Blades	=	4
H = Draught	=	24	Diam = D.	=	13.5
Δ = Displacement	=	14250	Pitch = P	=	11.75
Nominal Block Coeff	=	.787	PA ÷ DA	=	.357
M. S. Coeff	=		¾ x PA ÷ DA	=	.268
H ÷ B	=	.40	T. S	=	6260
Type	=	2	P x R	=	1735
B ÷ L	=	.1365	I - S	=	.858
B.C. on line C-D	=	.677	V	=	14.68
B.C. on line C-D Corrected for H/B	=	.65	I.T$_d$	=	3.08
Slip B.C. line X=.67 Y=.698	=	.684	I.H.P.	=	7710
LAB	=	162.5	P. C	=	.648
2 LAB ÷ H	=	13.55	E.H.P	=	5000
S = Basic Slip	=	.142	S.H.P.	=	7090
K.B.C. Line X=.696 Y=.722	=	.709			
K	=	1.37			

v	11.64
e.hp Estimated	1695
e.hp. ÷ E.H.P.	.339
10^{2p}	3.09
S.H.P$_d$	3140
Estimated SHP = IHP$_d$ x .75	3160
v ÷ V	.794
10^{2s}	1.61
R_d	113
Actual	109.92

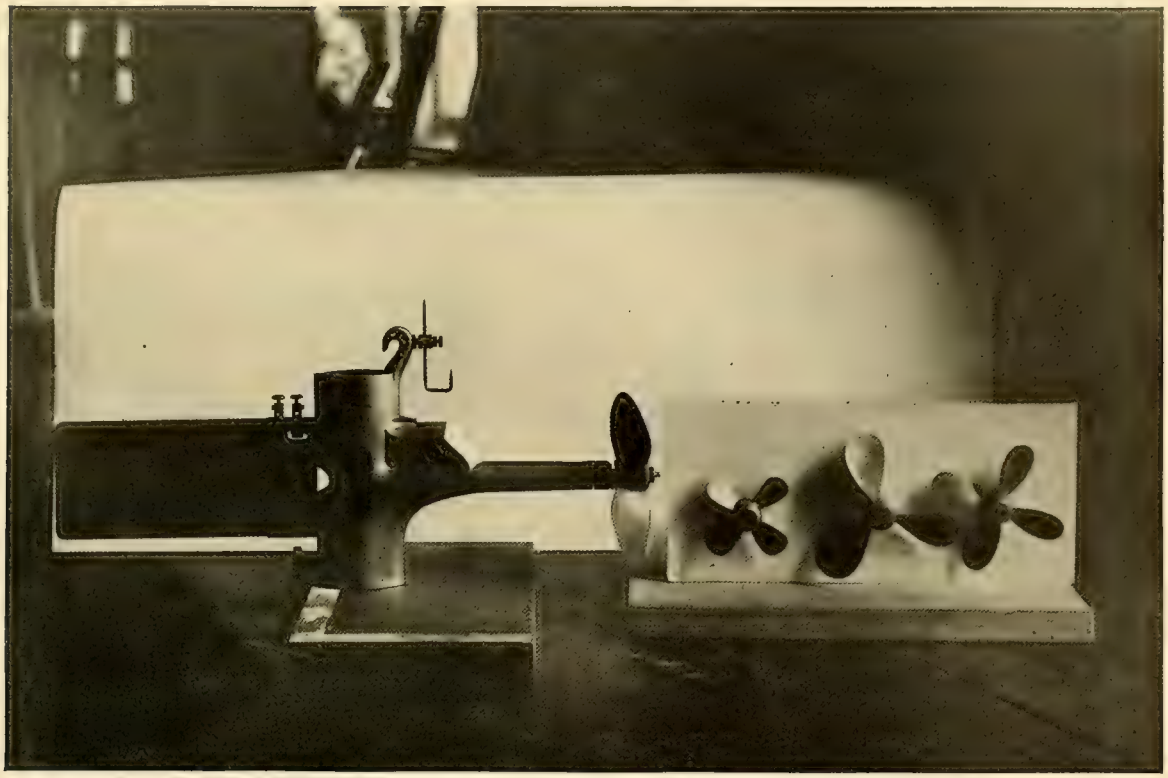
To illustrate paper on "The Application of Dyson's Method to Propellers of Ocean Going Vessels," by E. A. Stevens, Jr., Esq., Member.

PROBLEM No 14

Hull			Propeller	Wing	Centre
L = LW.L or LBP	=	500	No of Propellers	= 2	1
B = Beam	=	63	No of Blades	= 3	3
H = Draught	=	20.458	Diam = D.	= 9.167	9.167
Δ = Displacement	=	9612	Pitch = P	= 8.346	8.346
Nominal Block Coeff	=	.522	PA ÷ DA	= .516	.516
M. S. Coeff About	=	.935	~~a·PA÷DA~~	=	
H ÷ B	=	.325	T. S	= 11040	11040
Type	=	3	P x R	= 3200	3200
B ÷ L	=	.126	1 - S	= .828	.888
B.C. on line A-B	=	.388	V	= 26.2	28.1
BC on line A-B Corrected for $\frac{H}{B}$	=	.375	I.T$_d$.	= 9.23	9.23
Slip BC line X for Wing W for Centre	=	Wing .474 / Centre .530	I.H.P each	= 8500	8500
LAB Estimated	=	200	P. C	= .546	.546
2 LAB ÷ H	=	19.55	E.H.P.	= 4645	4645
S = Basic Shp	=	.172 / .112	S.H.P.	= 7810	7810
K.B.C. line X for Wing " W " Centre	=	.485 / .542			
K	=	1.0 / 1.12			

V	23.99		23.194		21.088		18.839		16.541	
	Wing	Centre	Wing	Centre	Wing	Centre	Wing	Centre	Wing	Centre
v ÷ V	.916	.855	.885	.825	.805	.751	.72	.671	.631	.59
10^{2S}	1.06	1.3	1.17	1.44	1.54	1.89	2.125	2.61	3.116	3.775
Actual SHP$_d$ each	8889	7767	7525	6925	5048	4995	3495	3705	2008	2199
S	208	.145	.194	.143	.172	.135	.164	.139	.138	.119
R_d	368	340	349	328.5	309.5	297	274	266	233.5	228
Actual R_d	367	338.7	349.8	326.6	310.9	294.4	276.1	264.9	234.4	233.4
$10^{2P} = \frac{SHP \times K}{SHP_d}$	.878	1.125	1.039	1.263	1.548	1.735	2.235	2.36	3.89	3.98
e.hp ÷ E.H.P.	1.133	.893	.964	.80	.657	.588	.461	.438	.2715	.2655
ehp for each screw	5260	4145	4470	3715	3055	2730	2140	2035	2160	1232
Total ehp = 2 Wing + Center	14665		12655		8840		6315		3752	
ehp Bare Hull	12420		10975		8250		5790		3520	
Total ehp ÷ ehp B.H	1.18		1.153		1.07		1.091		1.066	

To illustrate paper on "A Study of the Wake of Certain Models by Means of a Current Meter," by Professor E. M. Bragg, Member.



CURRENT METER AND WHEELS USED TO DETERMINE WAKE OF MODELS.

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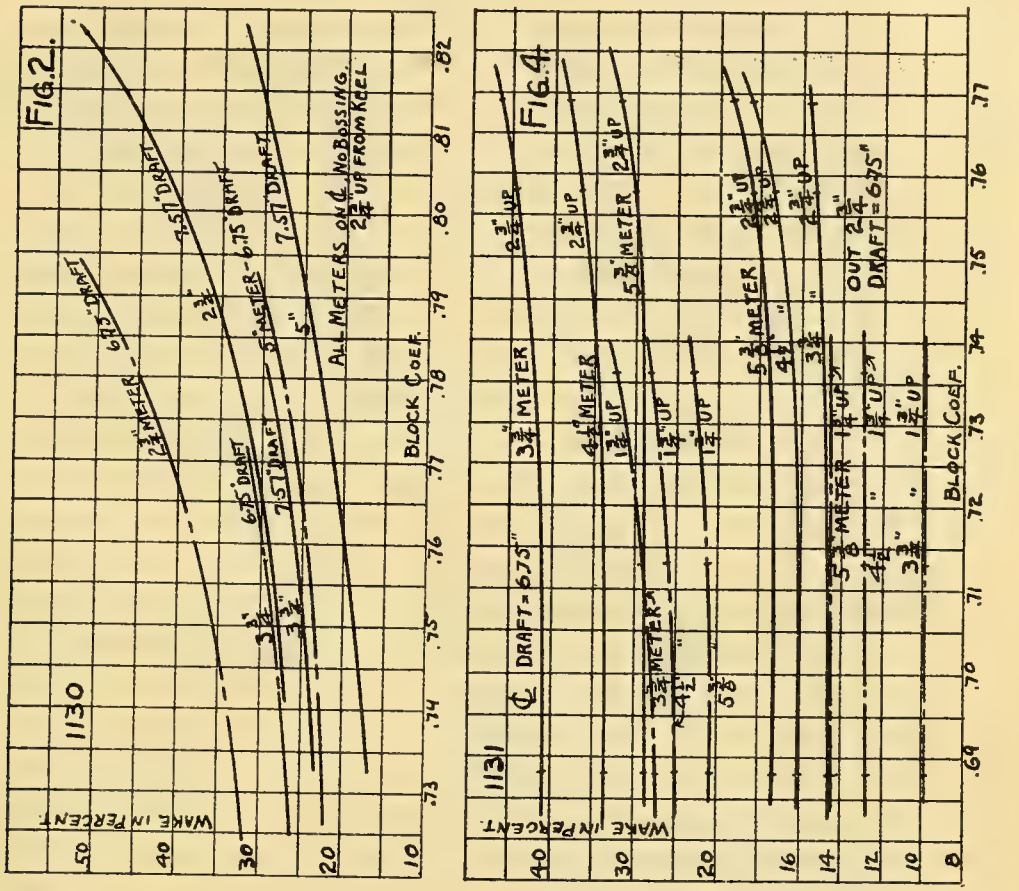

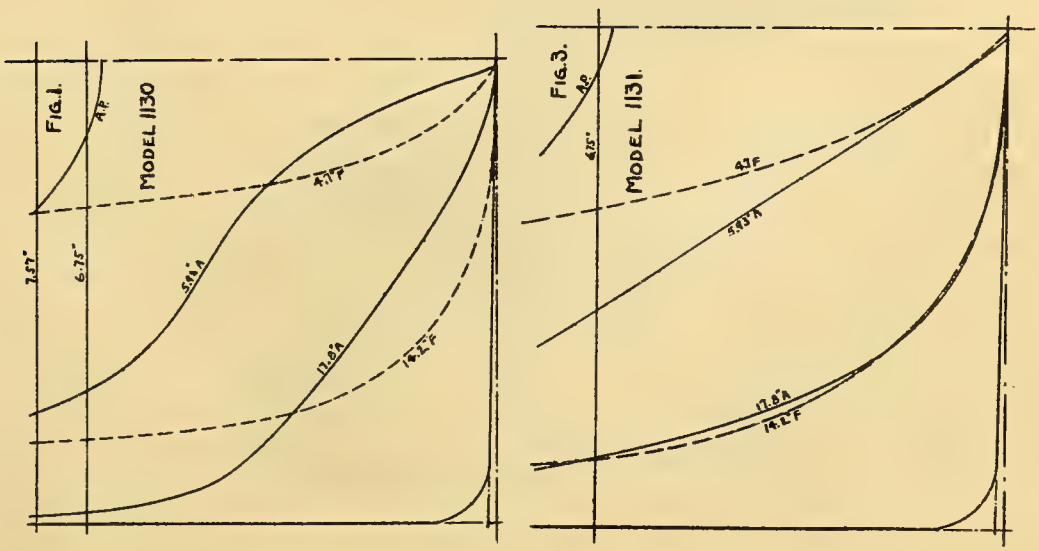

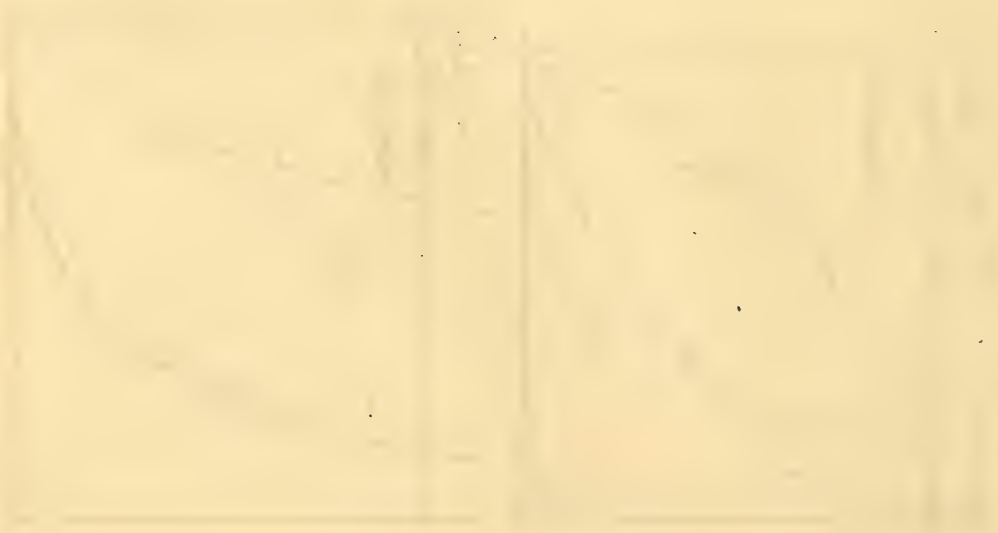

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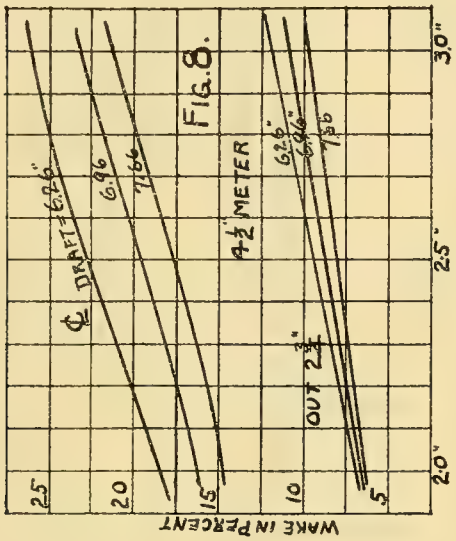

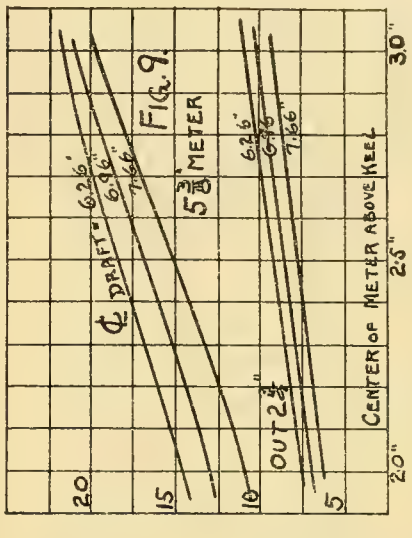

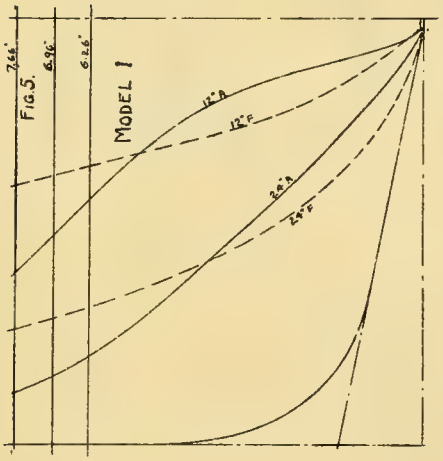

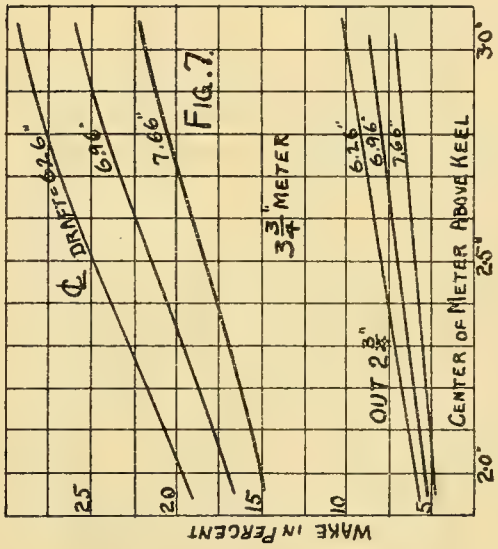

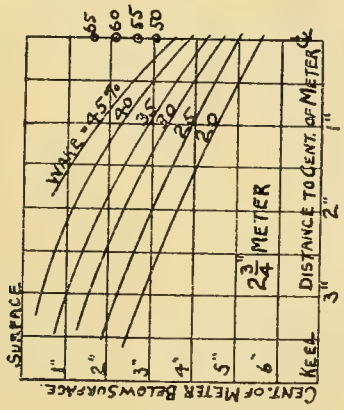

FIG. 6.

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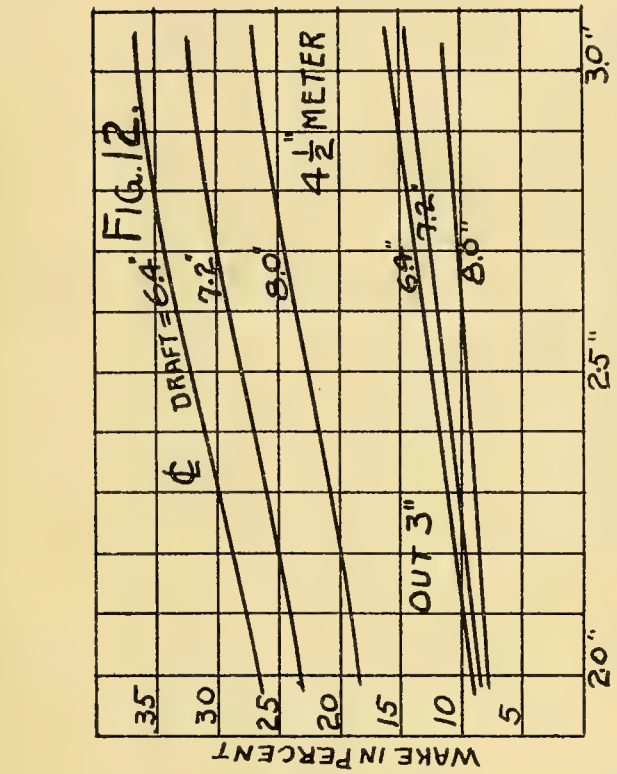

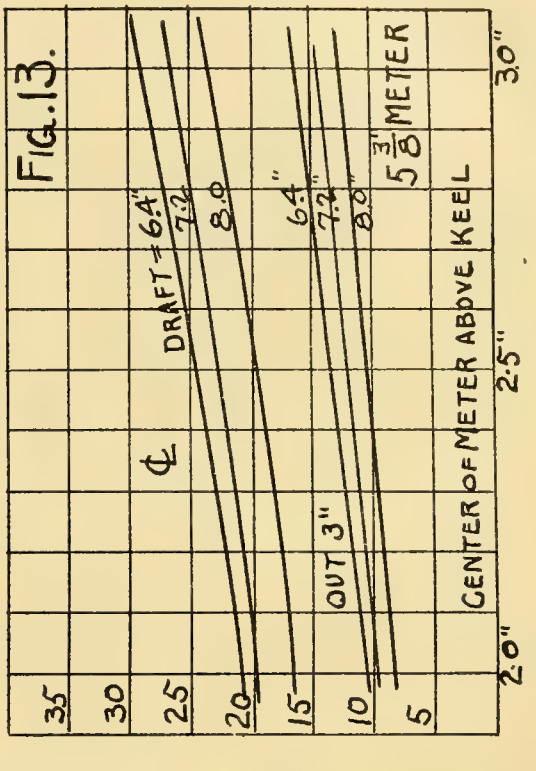

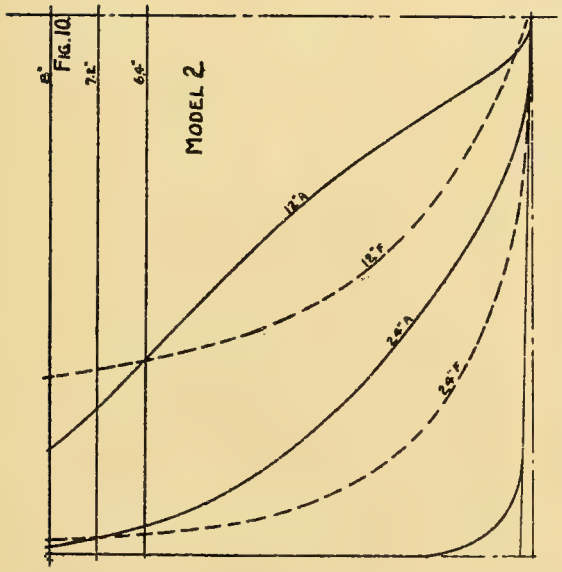

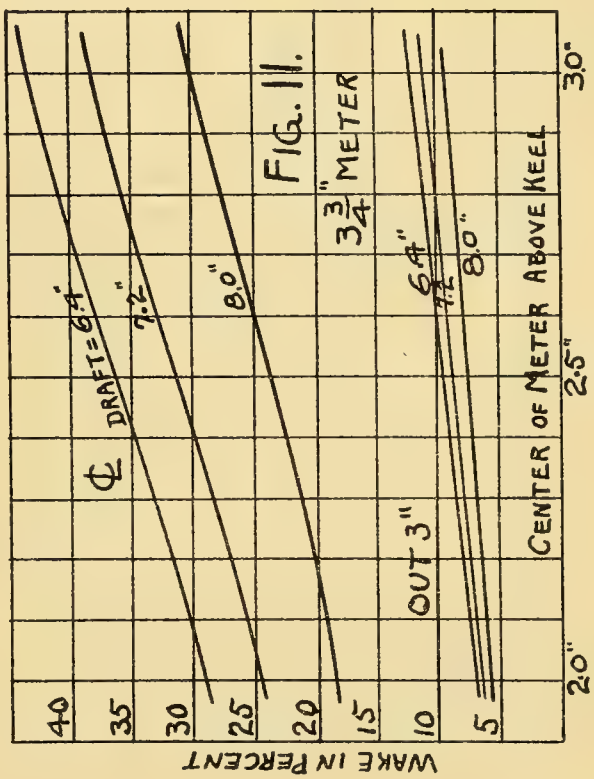

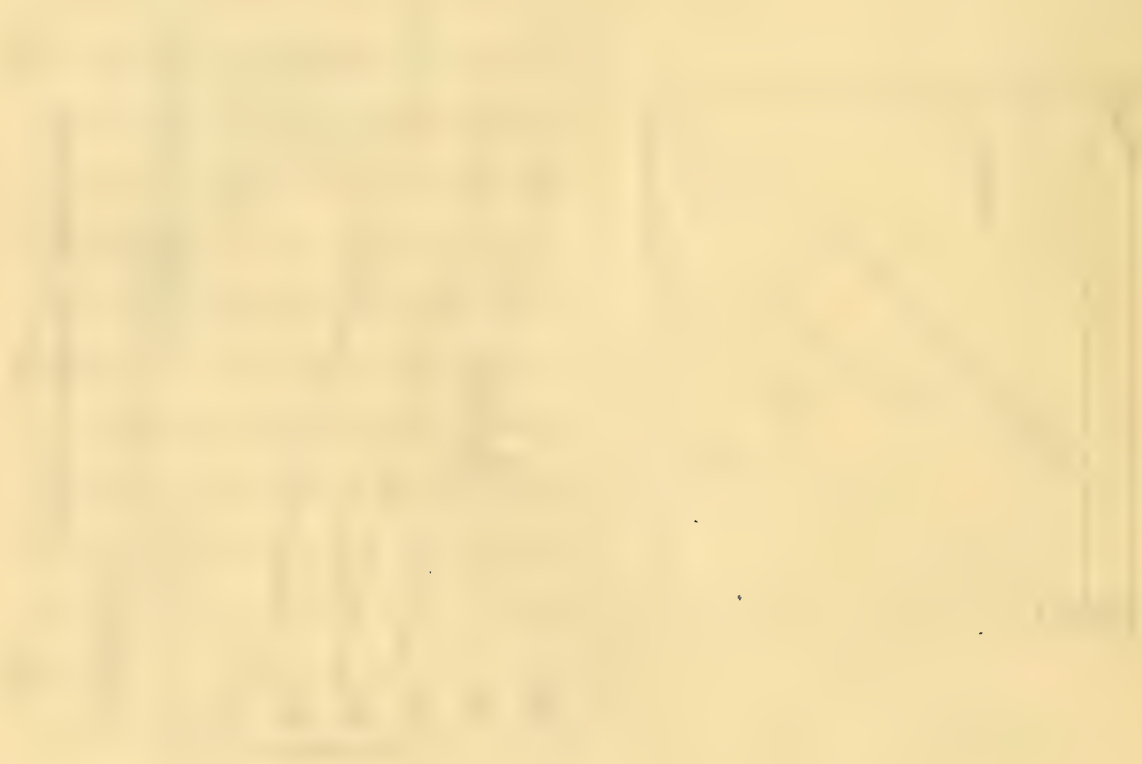

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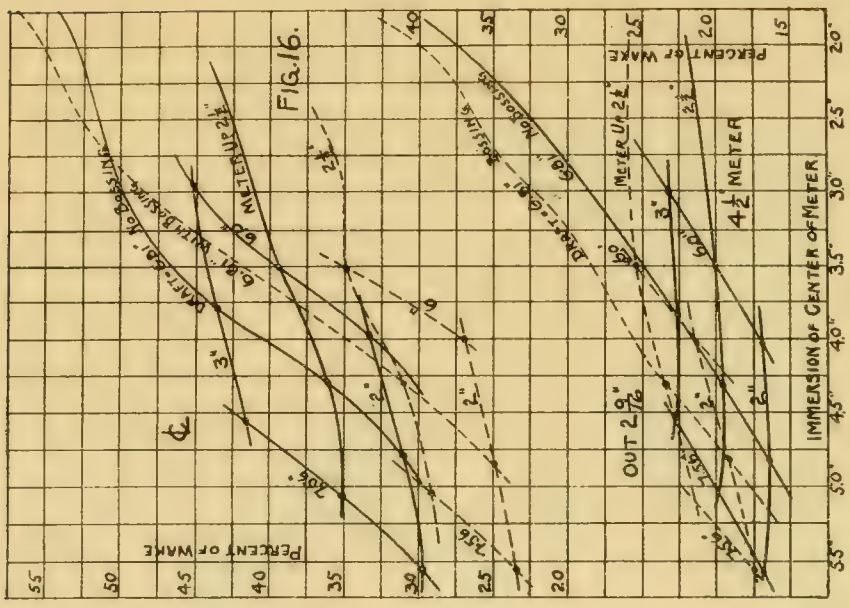

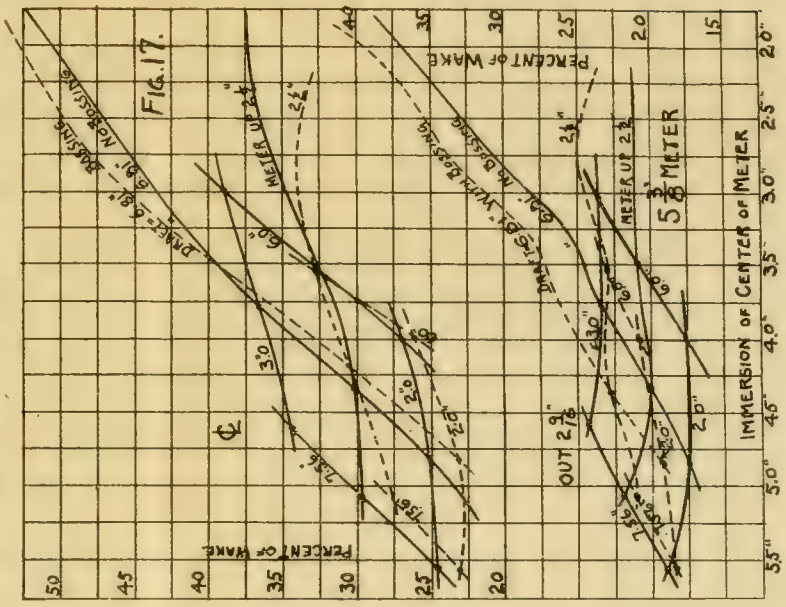

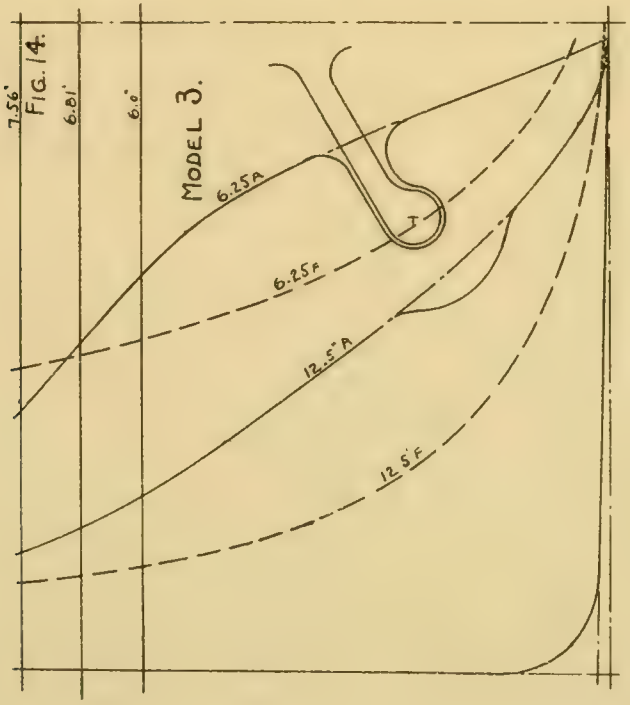

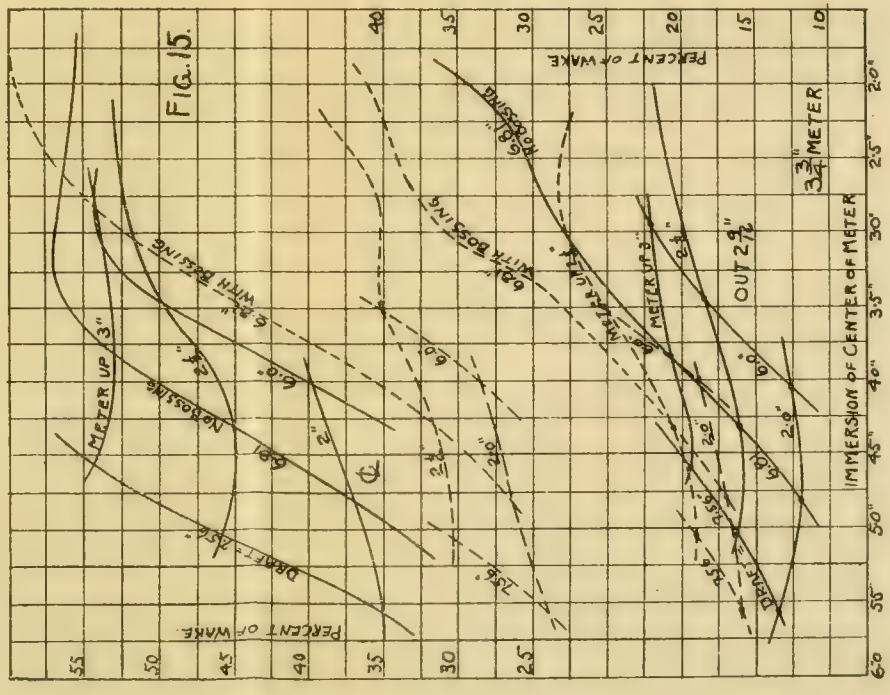

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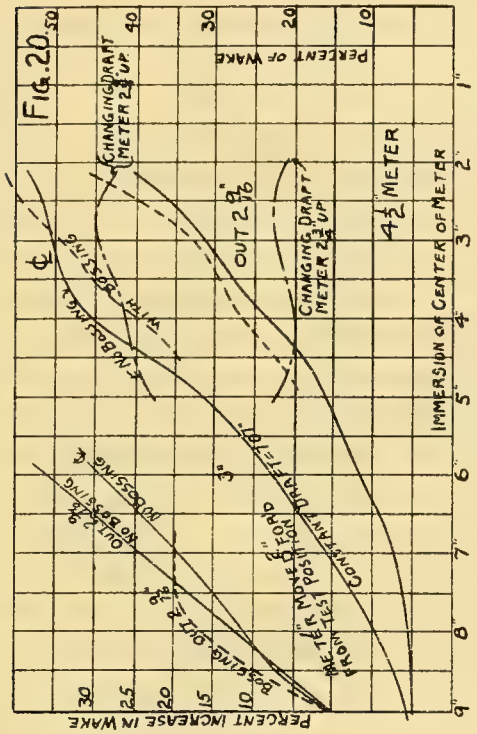

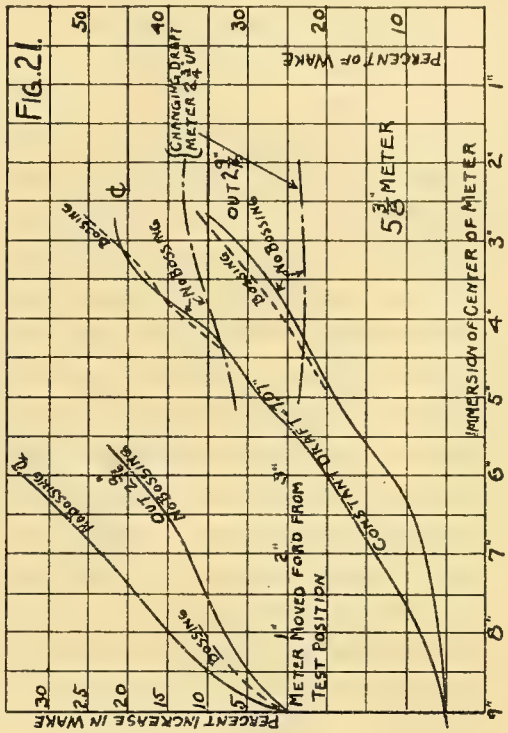

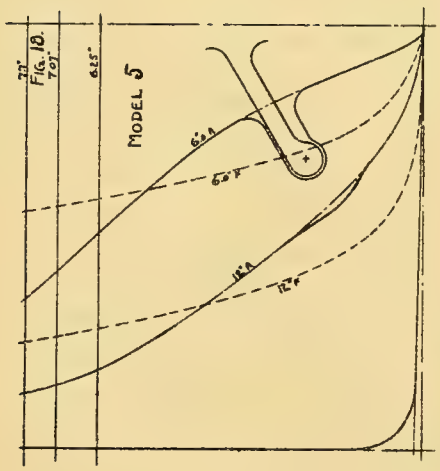

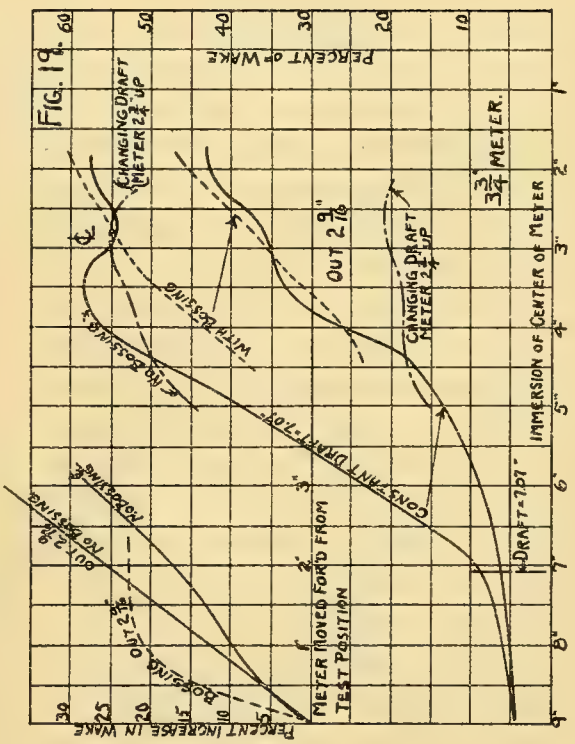

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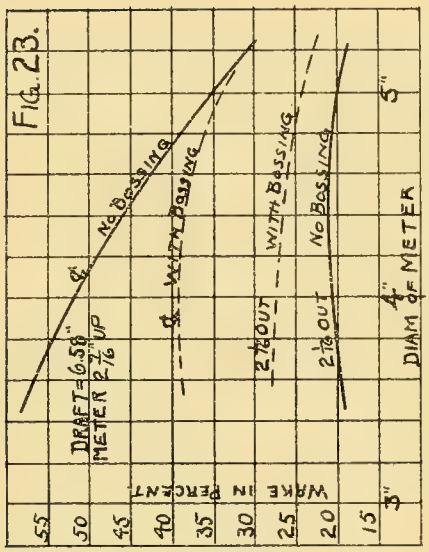


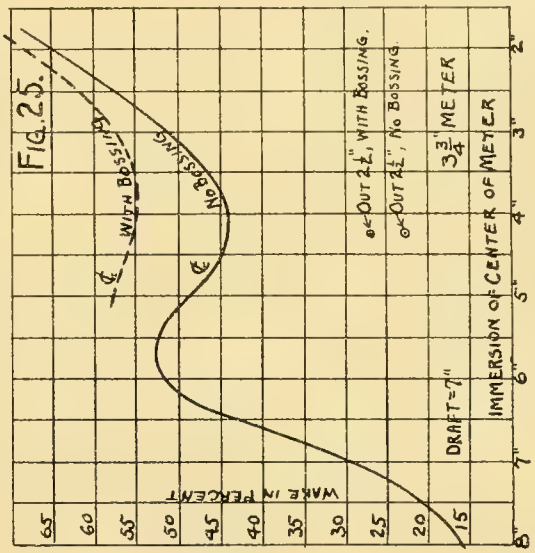
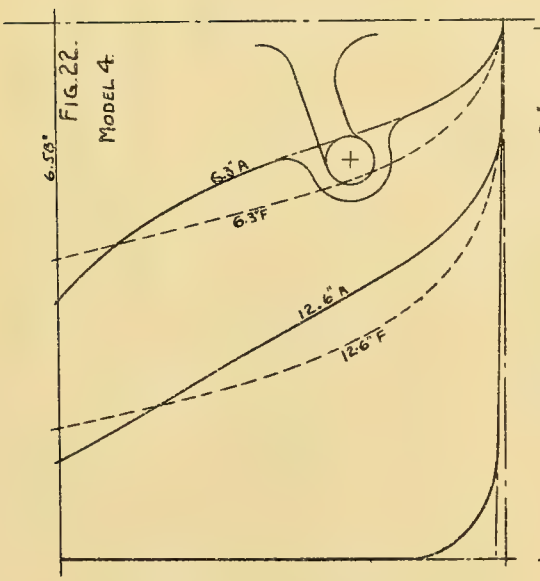
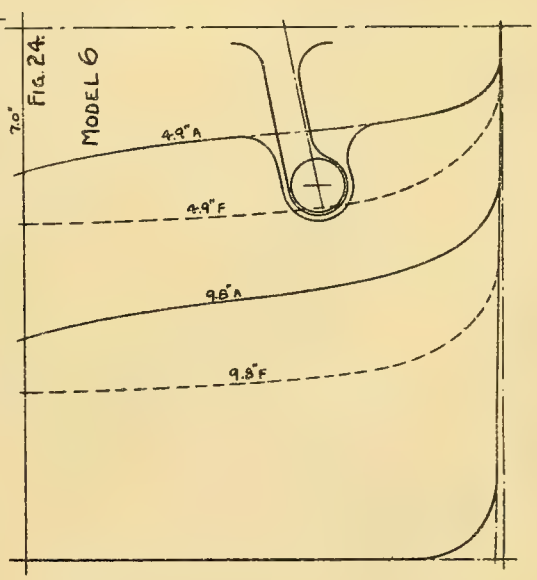
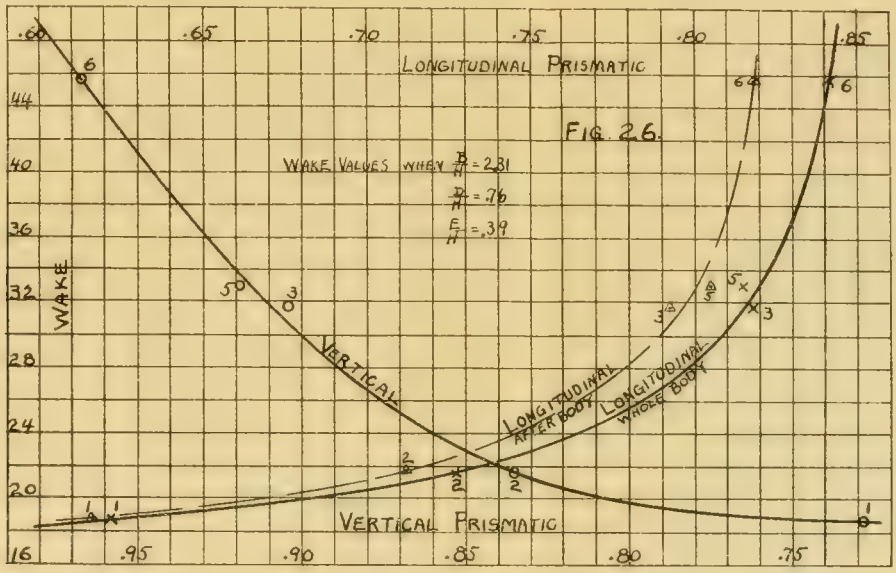


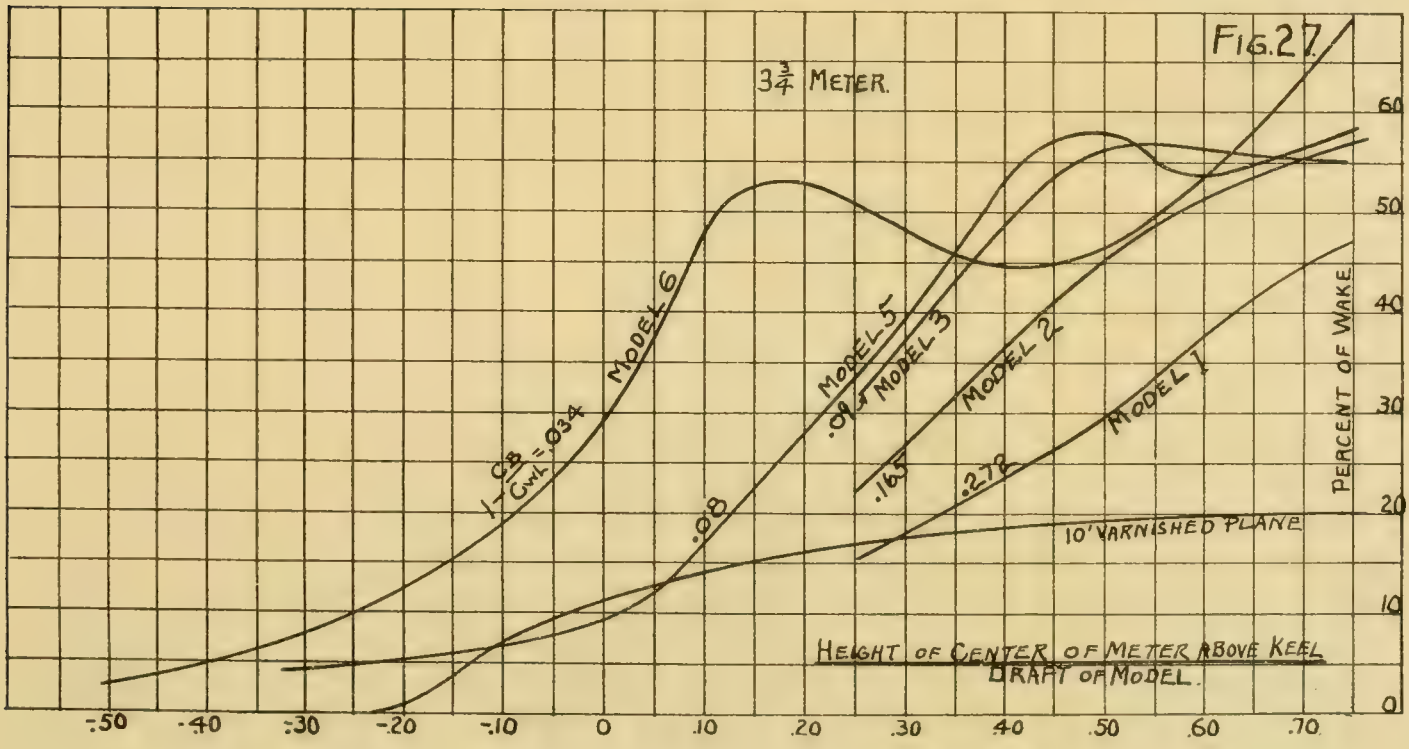
FIG. 25.
WAKE IN PERCENT
65 60 55 50 45 40 35 30 25 20 15
2" 3" 4" 5" 6" 7" 8"
IMMERSION OF CENTER OF METER
DRAFT=7"
3 3/4" METER
6" With Bossing
6" No Bossing
θ = OUT 2 1/2", WITH BOSSING.
θ = OUT 2 1/2", NO BOSSING





To illustrate paper on "A Study of the Wake of Certain Models by Means of a Current Meter," by Professor E. M. Bragg, Member.

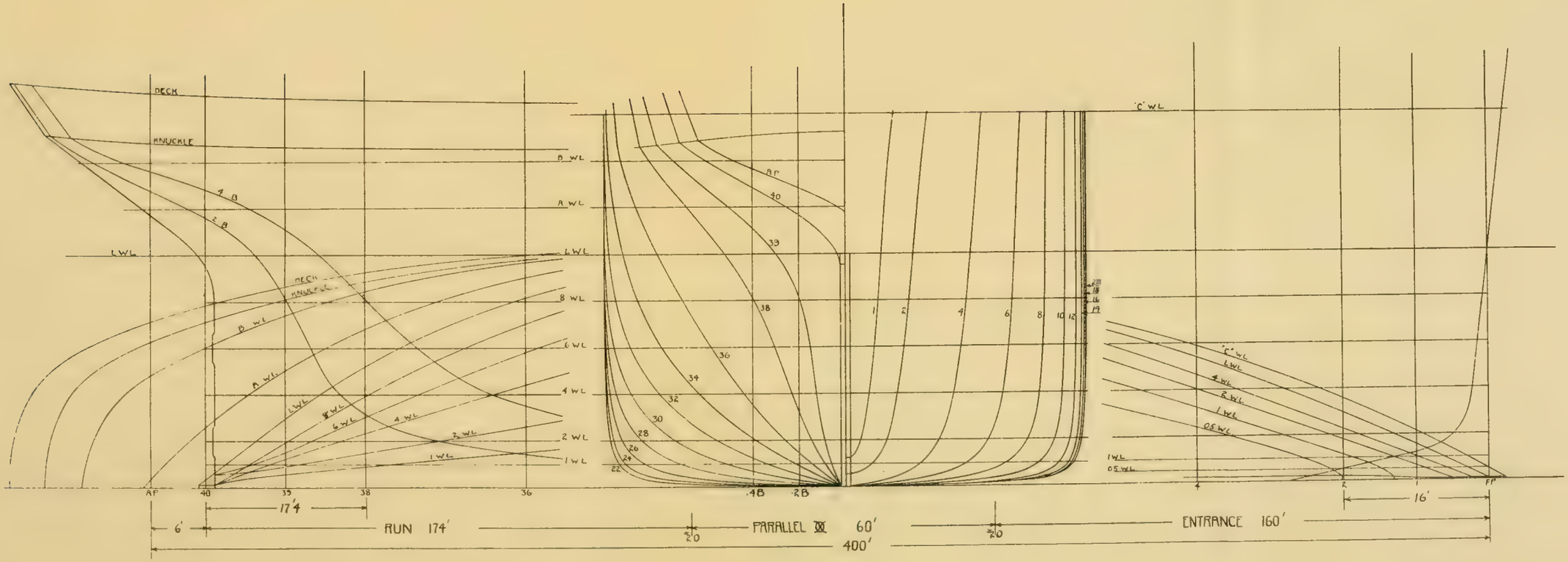




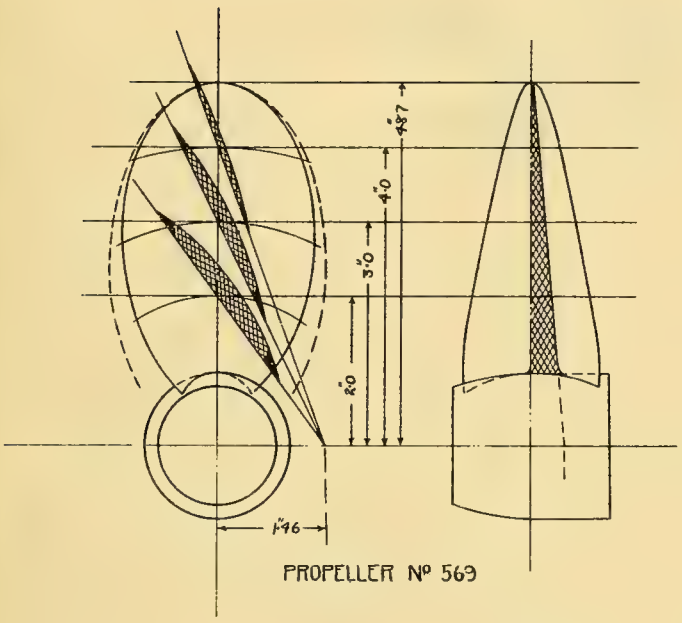
To illustrate paper on "Some Experiments on Propeller Position and Propulsive Efficiency," by Rear Admiral D. W. Taylor (C. C.), U. S. N., Honorary Vice-President.

FIG. 1
LINES OF MODEL Nº 2441
REPRESENTING
400 FT. SHIP

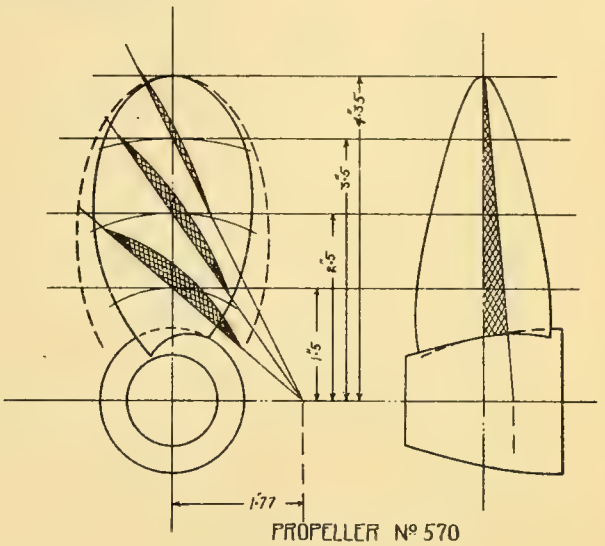
LENGTH BETWEEN PERPENDICULARS	400′
BEAM	52′
DRAFT	25′
DISPLACEMENT IN SEA WATER	11,150 TONS
BLOCK COEFFICIENT	0·75
MIDSHIP SECTION COEFFICIENT	0·975
LONGITUDINAL COEFFICIENT	0·769



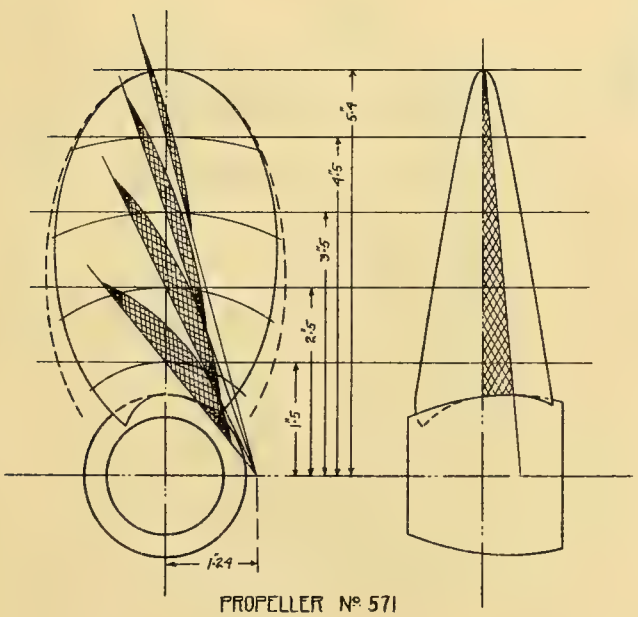
To illustrate paper on "Some Experiments on Propeller Position and Propulsive Efficiency," by Rear Admiral D. W. Taylor (C. C.), U. S. N., Honorary Vice-President.



PROPELLER Nº 569



PROPELLER Nº 570



PROPELLER Nº 571

PARTICULARS

PROPELLER Nº	DIAMETER INCHES	PITCH INCHES	PITCH RATIO	MEAN WIDTH RATIO	NUMBER OF BLADES	TOTAL PROJECTED AREA	PROJ AREA ÷ DISC AREA	BLADE THICKNESS FRACTION	
569	9·745	9·15	·939	·25	3	24·3	·325	.045	M. H.
570	8·700	11·123	1·278	"	"	17·6	·296	"	"
571	10·795	7·76	·719	"	"	31·6	·345	"	"

FIG. 2
MODEL PROPELLERS
USED WITH
MODEL Nº 2441

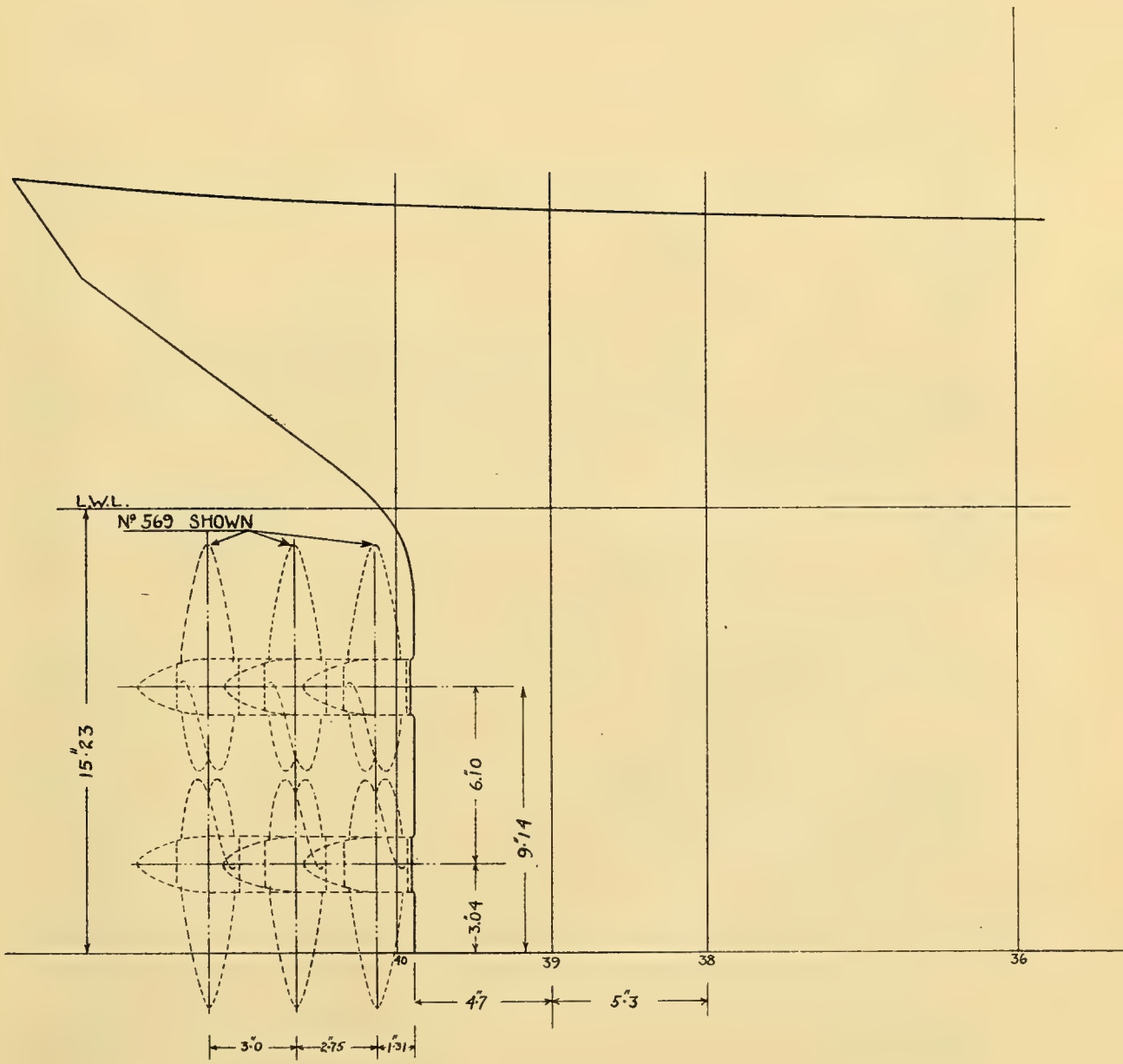
To illustrate paper on "Some Experiments on Propeller Position and Propulsive Efficiency," by Rear Admiral D. W. Taylor (C. C.), U. S. N., Honorary Vice-President.

FIG. 3

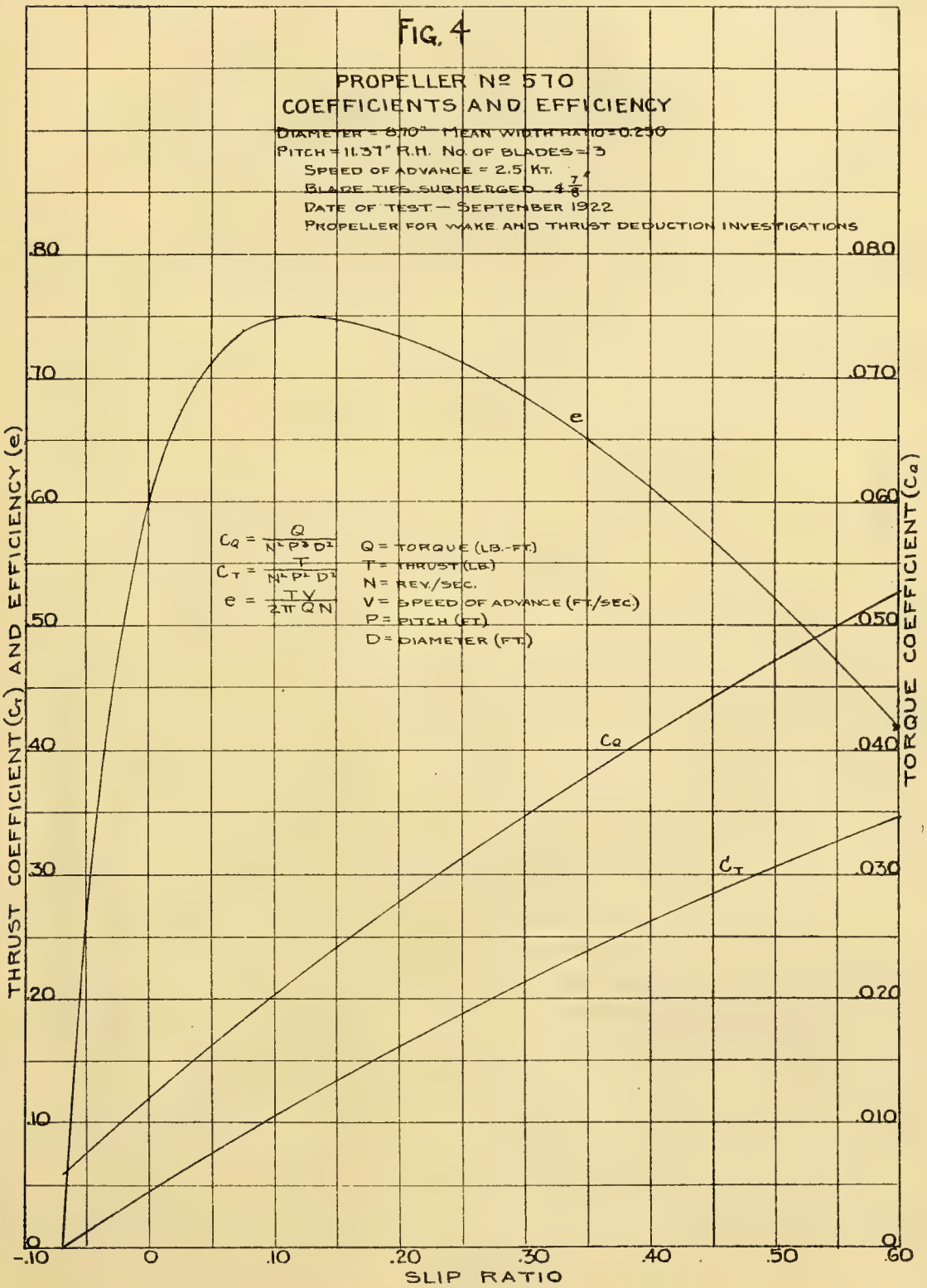
POSITIONS OF MODEL PROPELLERS

IN TESTS OF

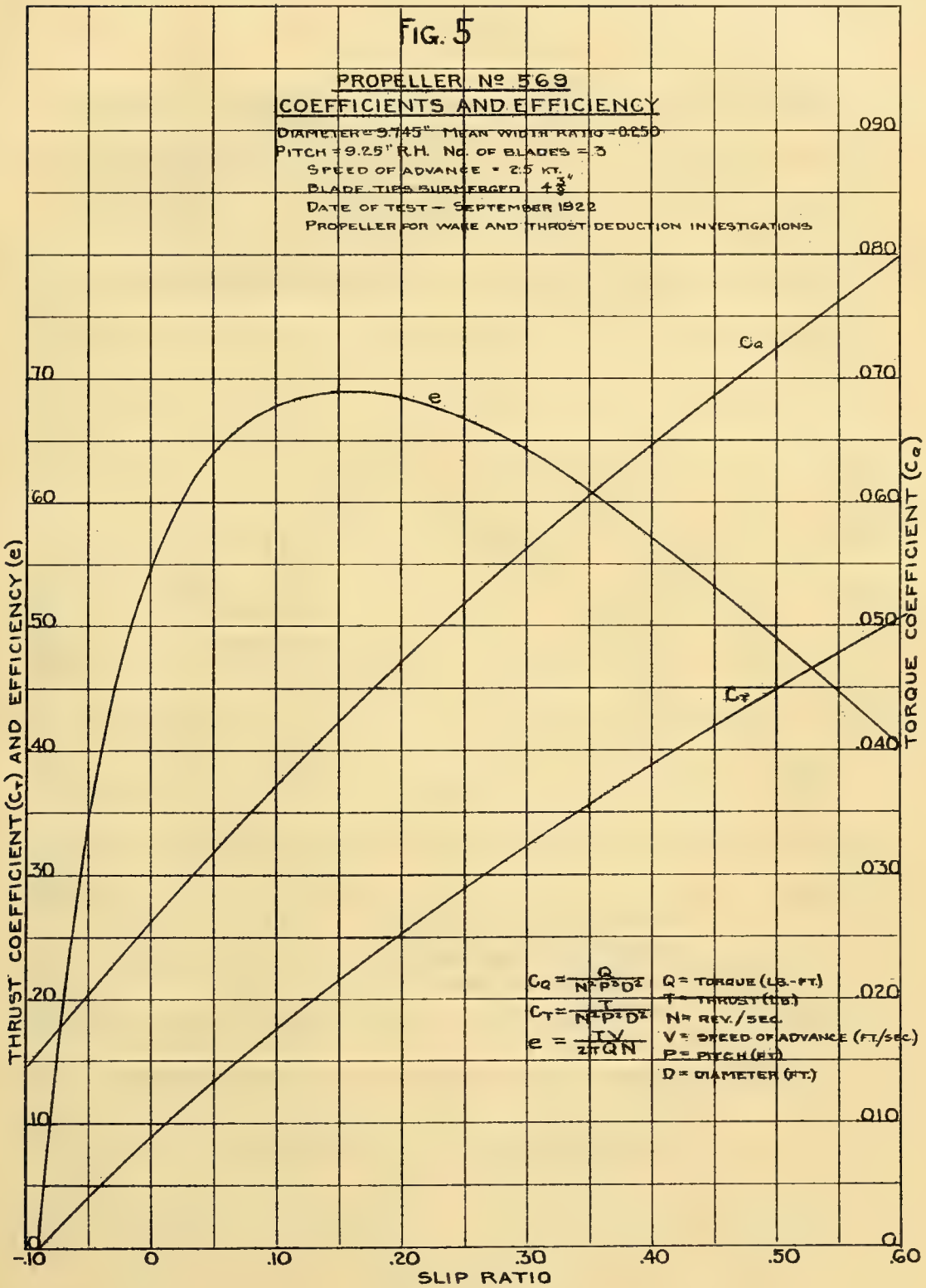
MODEL Nº 2441



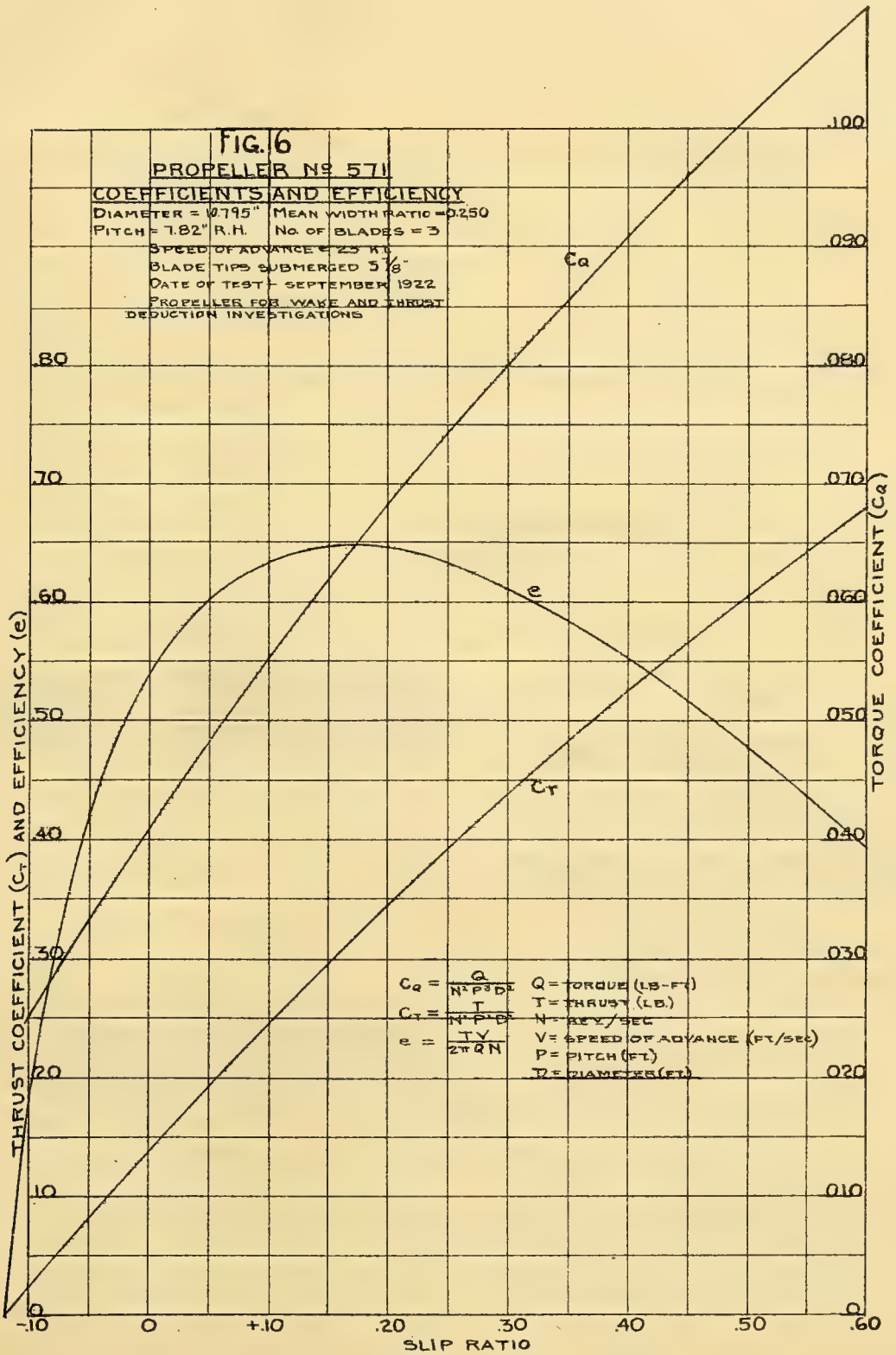
To illustrate paper on "Some Experiments on Propeller Position and Propulsive Efficiency," by Rear Admiral D. W. Taylor (C. C.), U. S. N., Honorary Vice-President.



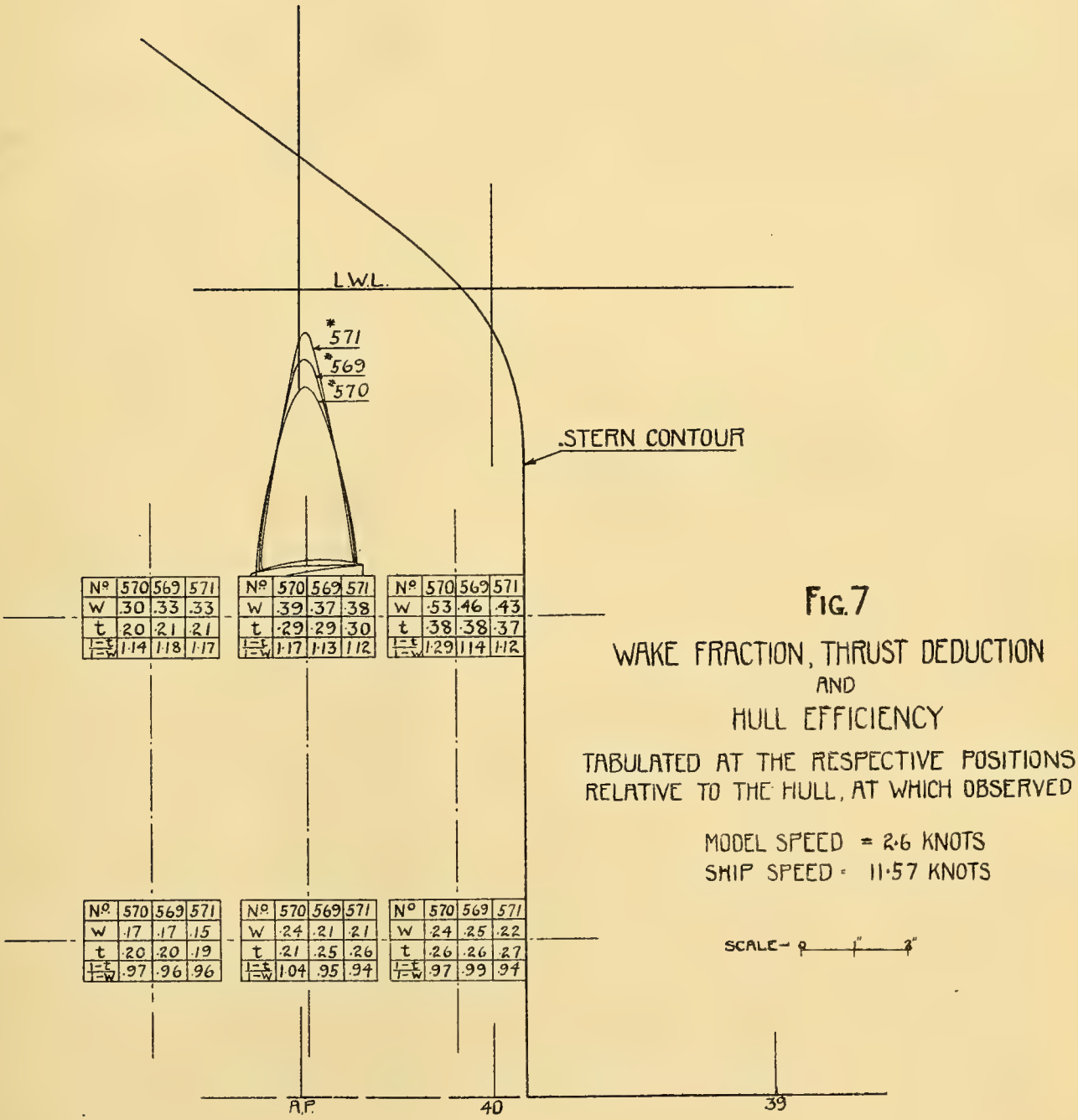
To illustrate paper on "Some Experiments on Propeller Position and Propulsive Efficiency," by Rear Admiral D. W. Taylor (C. C.), U. S. N., Honorary Vice-President.



To illustrate paper on "Some Experiments on Propeller Position and Propulsive Efficiency," by Rear Admiral D. W. Taylor (C. C.), U. S. N., Honorary Vice-President.



To illustrate paper on "Some Experiments on Propeller Position and Propulsive Efficiency," by Rear Admiral D. W. Taylor (C. C.), U. S. N., Honorary Vice-President.



Nº	570	569	571
w	.30	.33	.33
t	.20	.21	.21
$\frac{1-t}{1-w}$	1.14	1.18	1.17

Nº	570	569	571
w	.39	.37	.38
t	.29	.29	.30
$\frac{1-t}{1-w}$	1.17	1.13	1.12

Nº	570	569	571
w	.53	.46	.43
t	.38	.38	.37
$\frac{1-t}{1-w}$	1.29	1.14	1.12

Nº	570	569	571
w	.17	.17	.15
t	.20	.20	.19
$\frac{1-t}{1-w}$	.97	.96	.96

Nº	570	569	571
w	.24	.21	.21
t	.21	.25	.26
$\frac{1-t}{1-w}$	1.04	.95	.94

Nº	570	569	571
w	.24	.25	.22
t	.26	.26	.27
$\frac{1-t}{1-w}$	.97	.99	.94

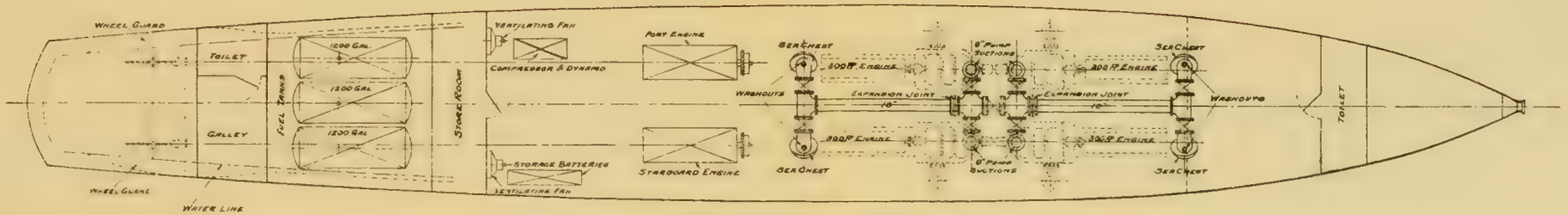
FIG. 7

WAKE FRACTION, THRUST DEDUCTION AND HULL EFFICIENCY

TABULATED AT THE RESPECTIVE POSITIONS RELATIVE TO THE HULL, AT WHICH OBSERVED

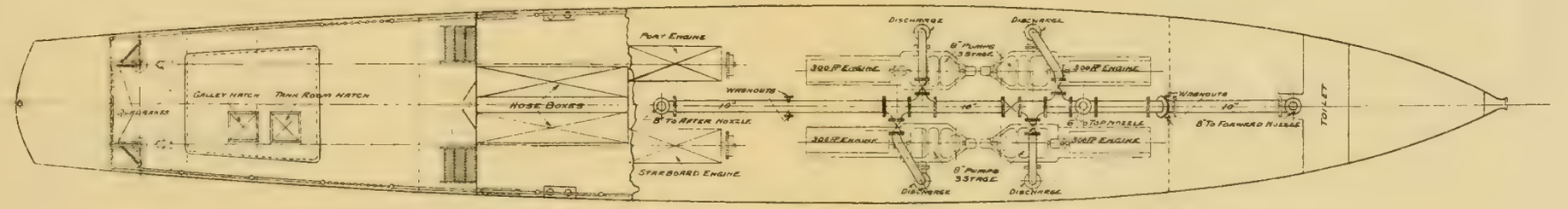
MODEL SPEED = 2·6 KNOTS
SHIP SPEED = 11·57 KNOTS

To illustrate paper on "A Sixteen Hundred and Fifty Horse-Power Fire Boat," by Arthur D. Stevens, Esq., Member.



PLAN, SHOWING SUCTION MAIN; ETC.

Fig 1.



PLAN, SHOWING DISCHARGE MAIN; ETC.

Fig 2.

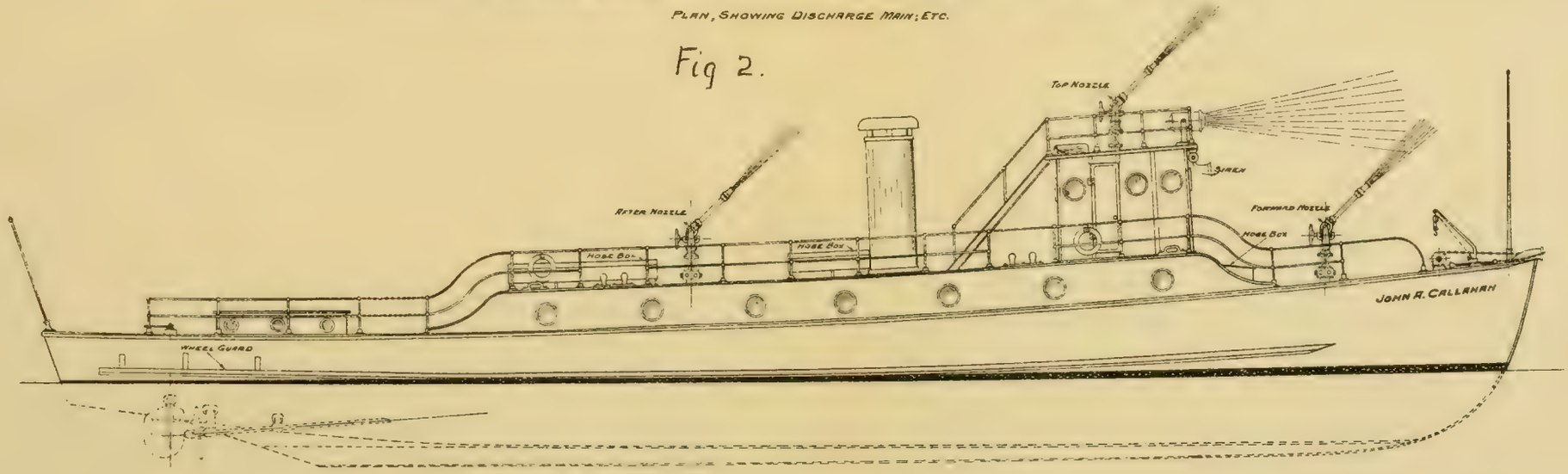


Fig 3.

PLAN SHOWING CONVERSION S.C.145 INTO FIREBOAT FOR CITY OF JACKSONVILLE FLORIDA

To illustrate paper on "A Sixteen Hundred and Fifty Horse-Power Fire Boat," by Arthur D. Stevens, Esq., Member.

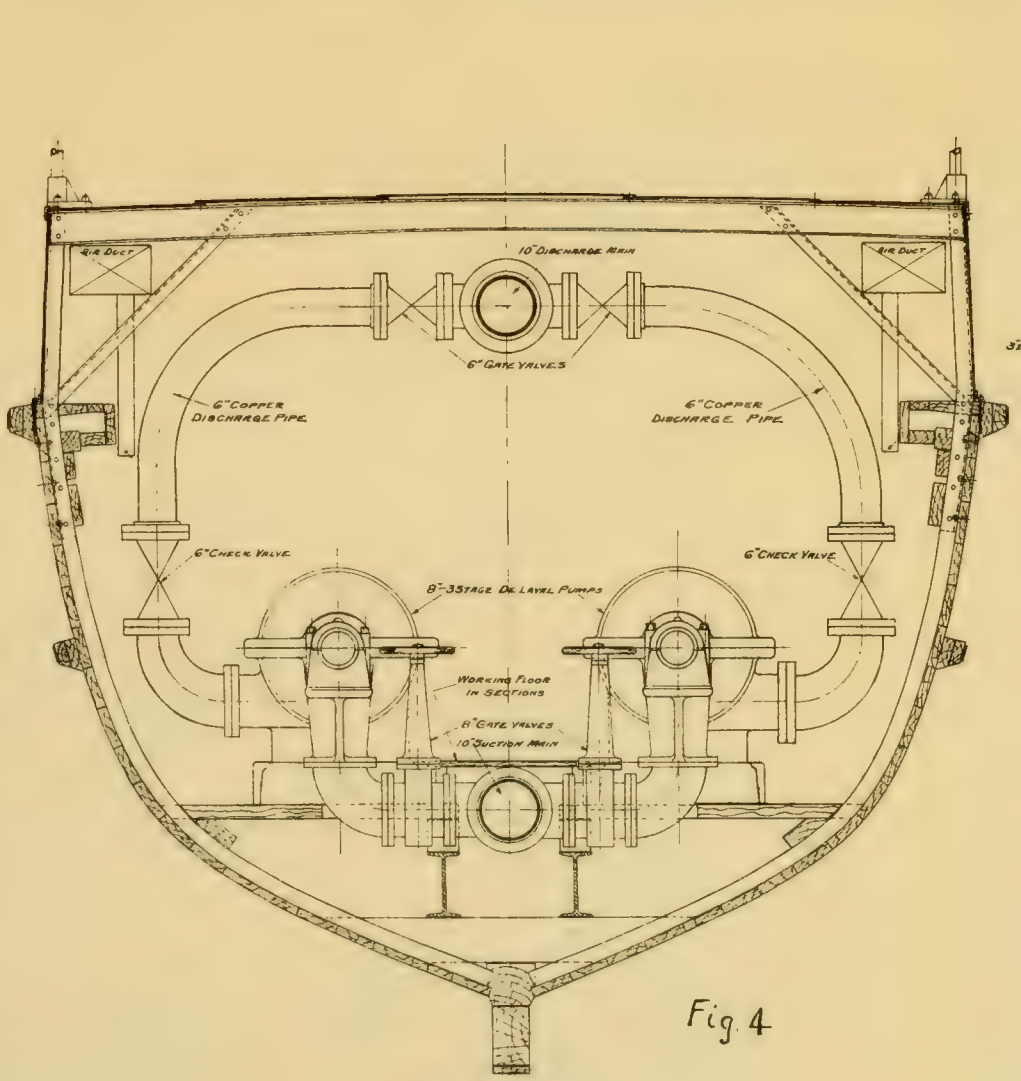


Fig. 4

SECTION AT FRAME 37
LOOKING FORWARD

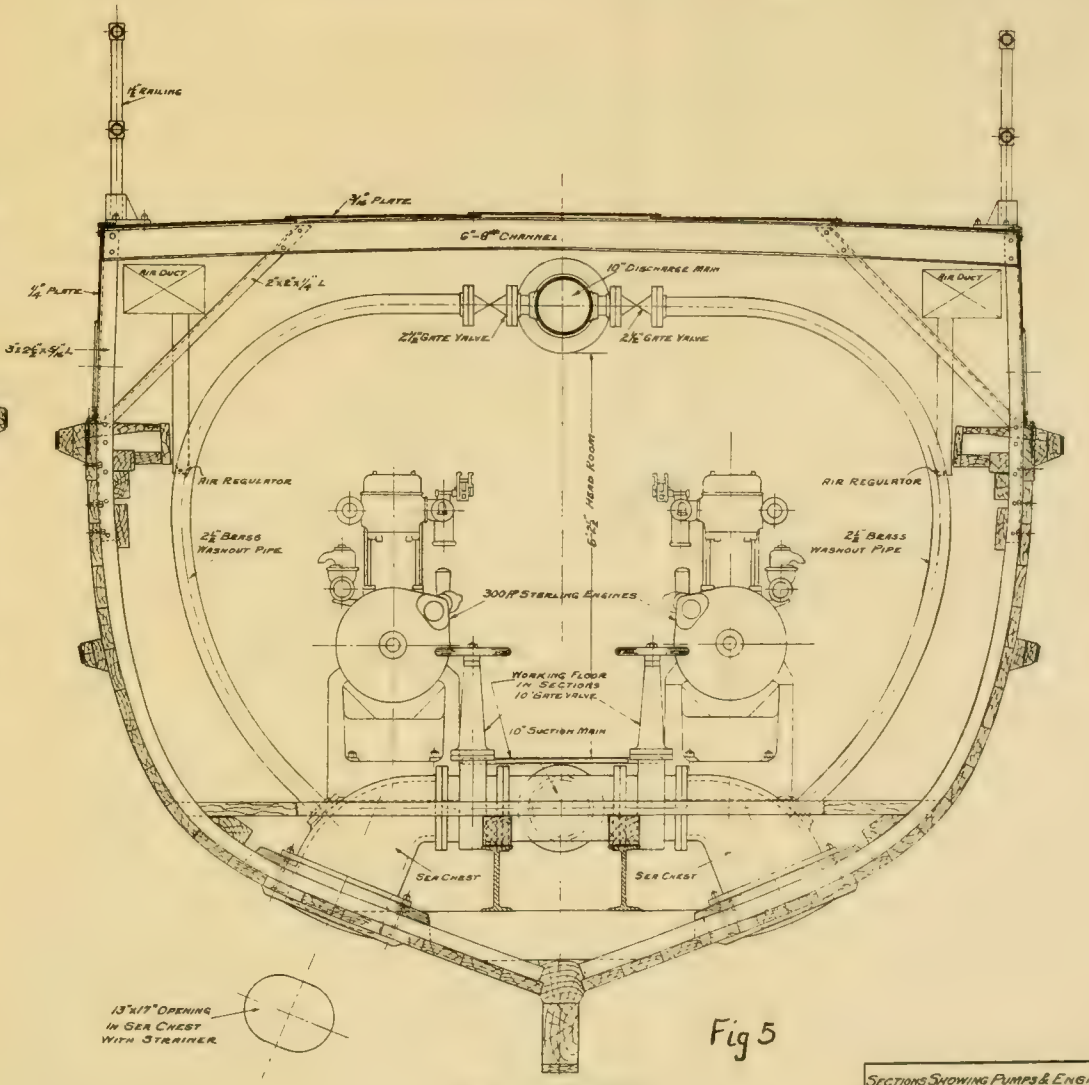
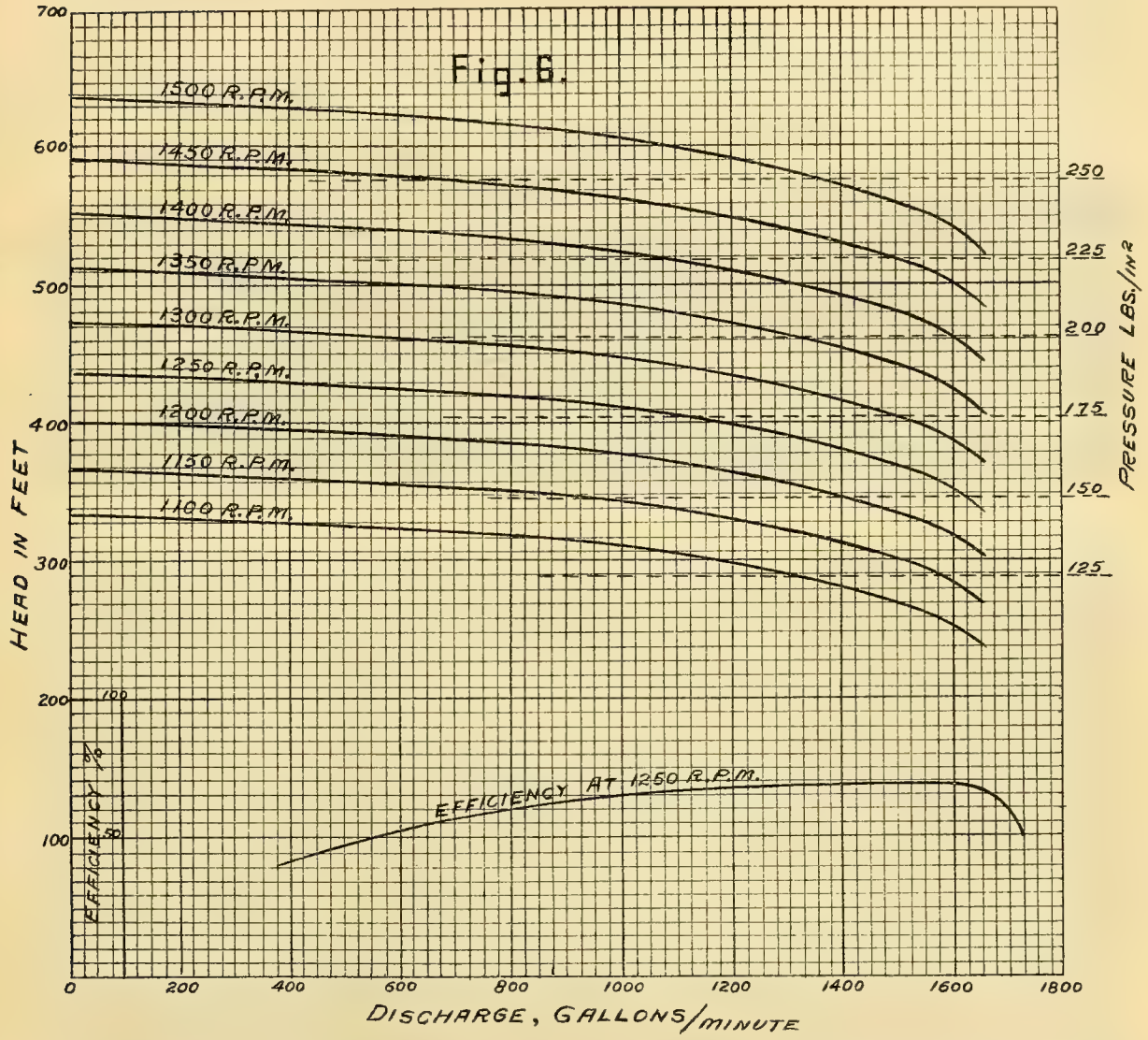


Fig 5

SECTION AT FRAME 52
LOOKING FORWARD

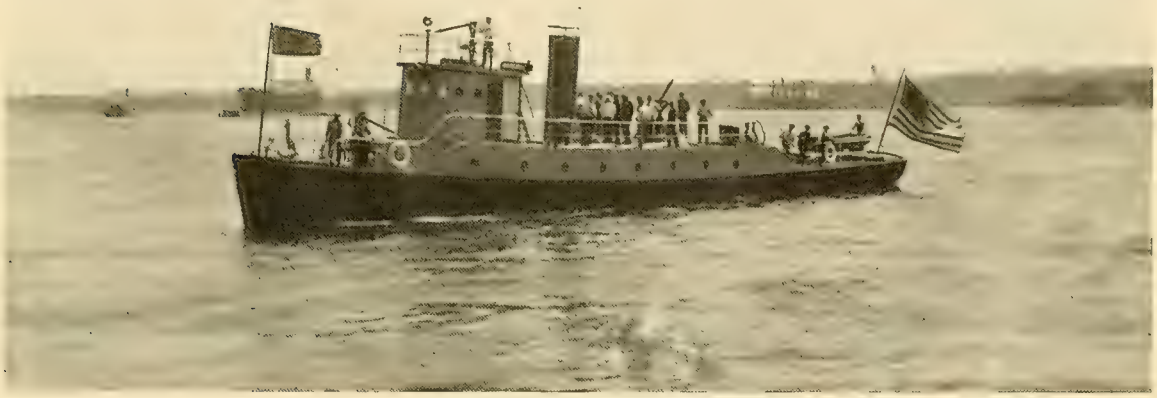
SECTIONS SHOWING PUMPS & ENGINES IN FIREBOAT FOR CITY OF JACKSONVILLE — FLORIDA

To illustrate paper on "A Sixteen Hundred and Fifty Horse-Power Fire Boat," by Arthur D. Stevens, Esq., Member.



PERFORMANCE DIAGRAM
OF
DE LAVAL 8"-3 STAGE, FIRE BOAT PUMP
FOR
CITY OF JACKSONVILLE

To illustrate paper on "A Sixteen Hundred and Fifty Horse-Power Fire Boat," by Arthur D. Stevens, Esq., Member.



Fire Boat John H. Callahan.

Three-Inch Stream, 335 Feet High, 250 Pounds Pressure.

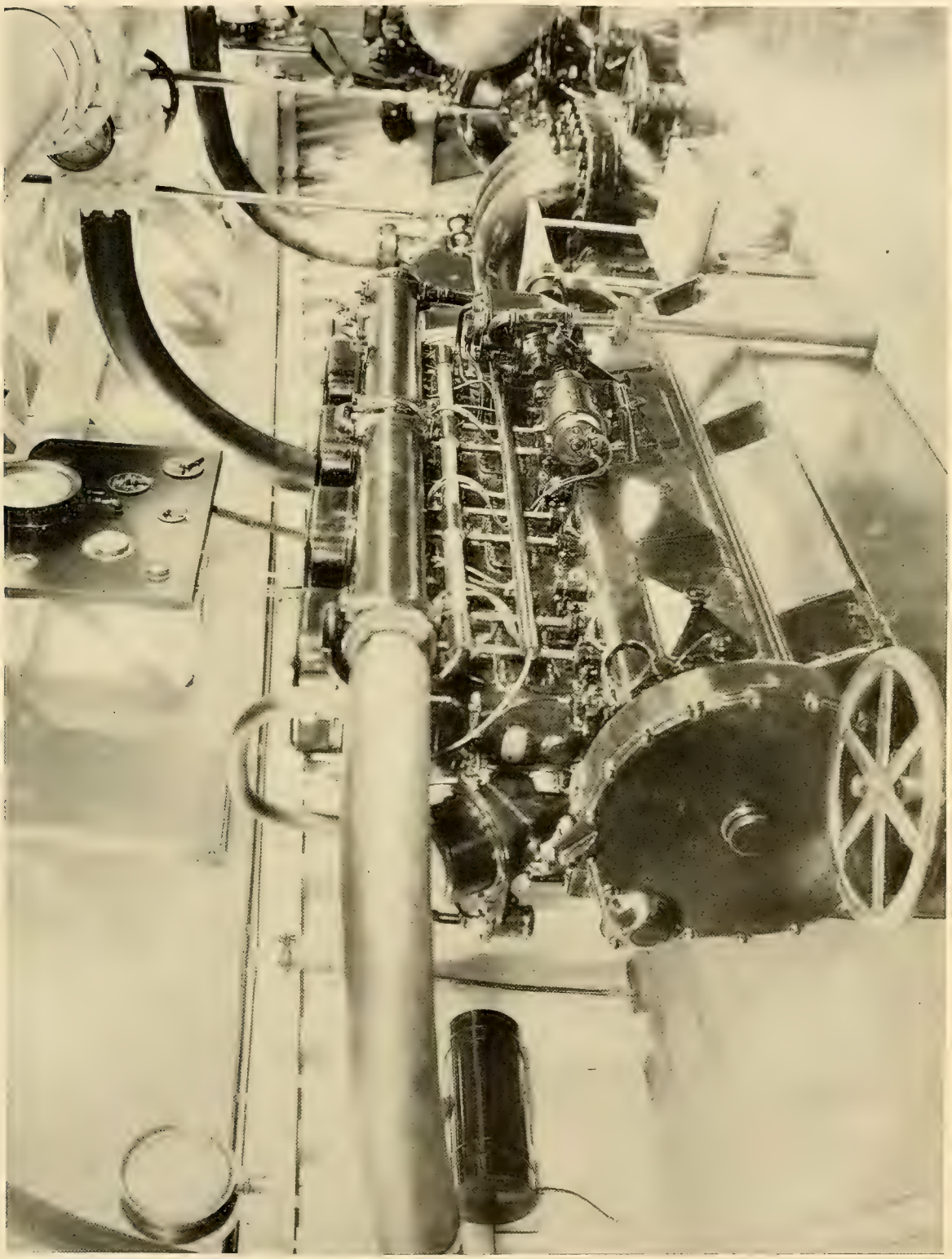
To illustrate paper on "A Sixteen Hundred and Fifty Horse-Power Fire Boat," by Arthur D. Stevens, Esq., Member.

THREE 2½-INCH STREAMS, 160 POUNDS PRESSURE.

To illustrate paper on "A Sixteen Hundred and Fifty Horse-Power Fire Boat," by Arthur D. Stevens, Esq., Member.

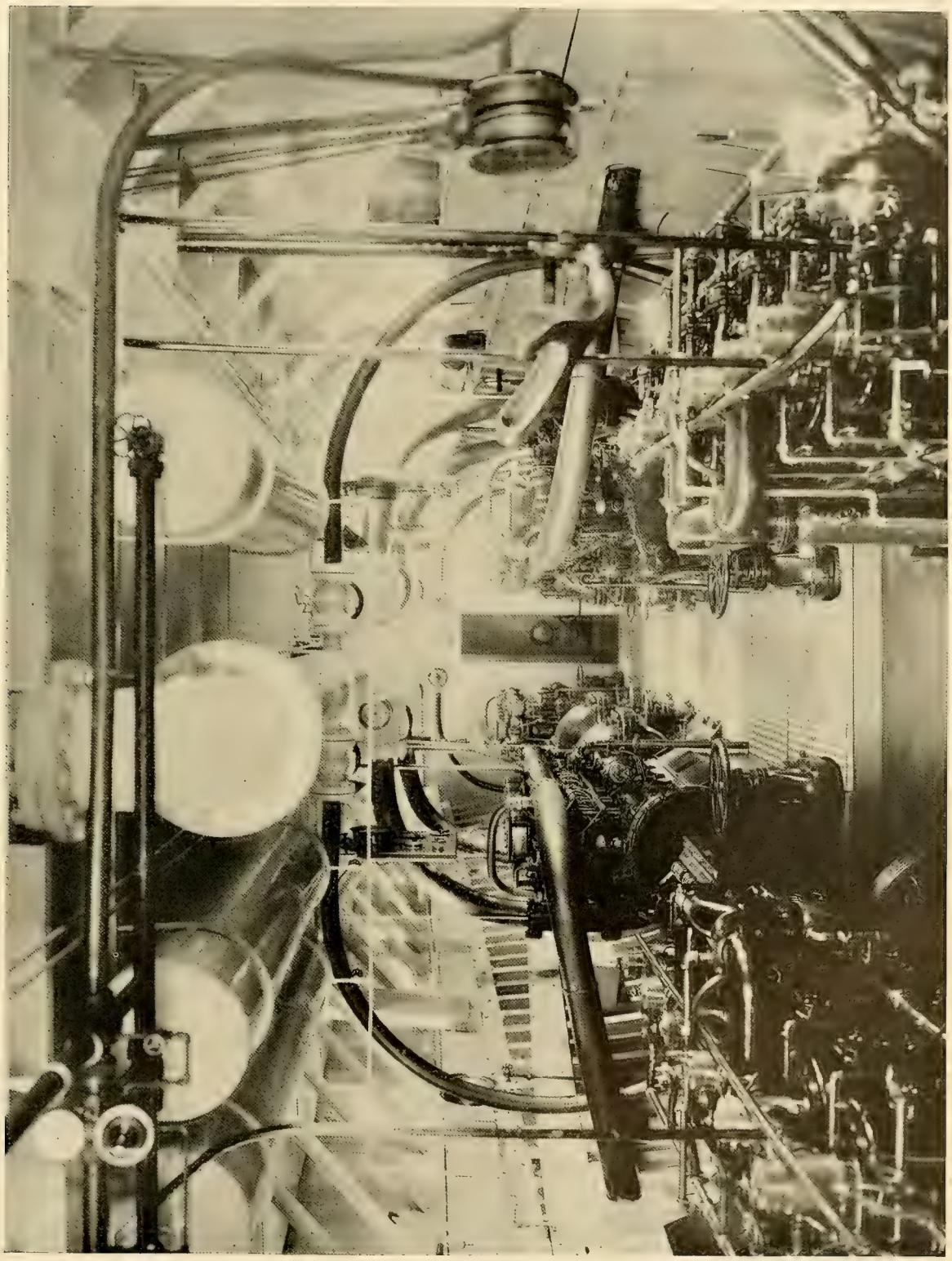
SEVEN STREAMS AT 140 POUNDS PRESSURE.

To illustrate paper on "A Sixteen Hundred and Fifty Horse-Power Fire Boat," by Arthur D. Stevens, Esq., Member.



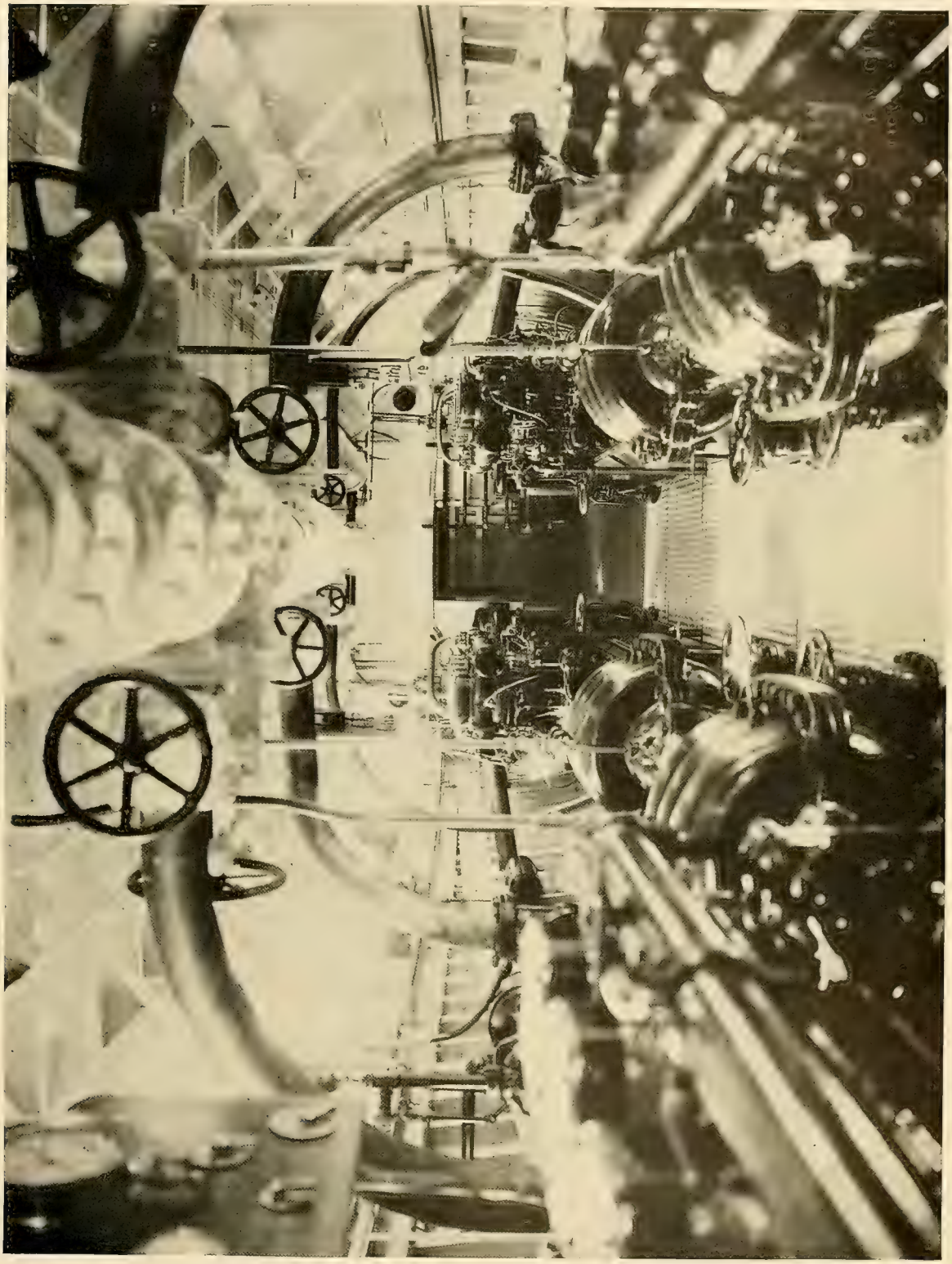
PORT AFTER PUMP UNIT.

To illustrate paper on "A Sixteen Hundred and Fifty Horse-Power Fire Boat," by Arthur D. Stevens, Esq., Member.



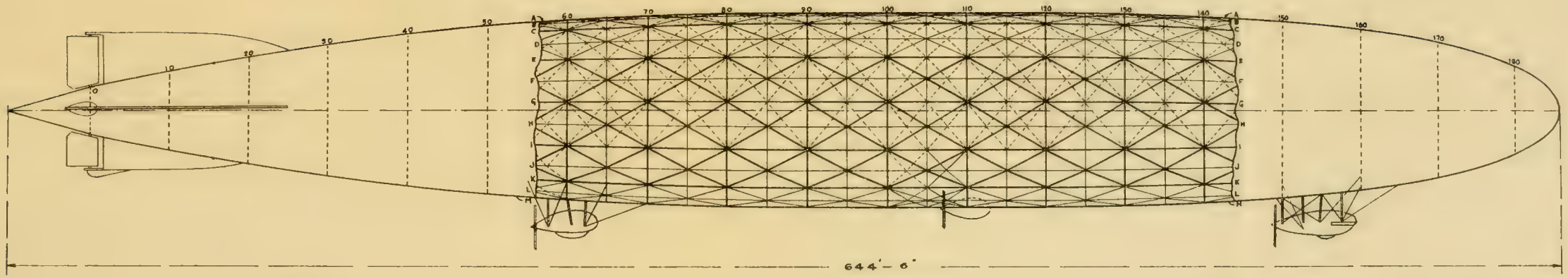
Engine Room, Looking Forward.

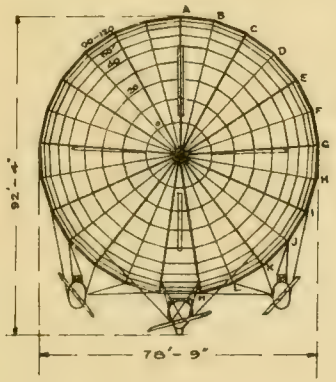
To illustrate paper on "A Sixteen Hundred and Fifty Horse-Power Fire Boat," by Arthur D. Stevens, Esq., Member.



ENGINE ROOM, LOOKING AFT.

To illustrate paper on "The Longitudinal Strength of Rigid Airships," by Professor William Hovgaard, Member.





GERMAN AIRSHIP

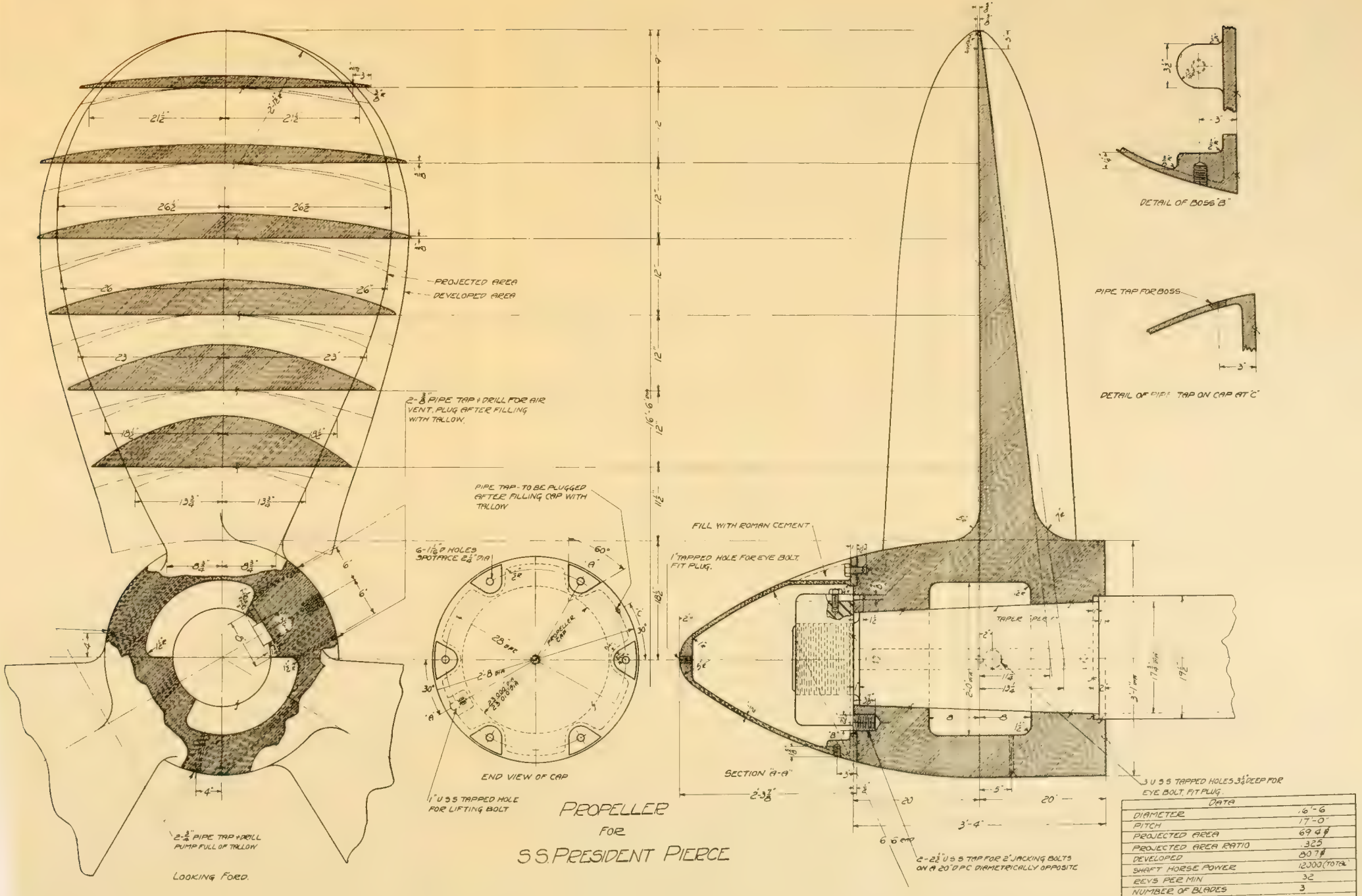
L—49

GENERAL ARRANGEMENT

OF

LONGITUDINALS, TRANSVERSES, AND WIRING.

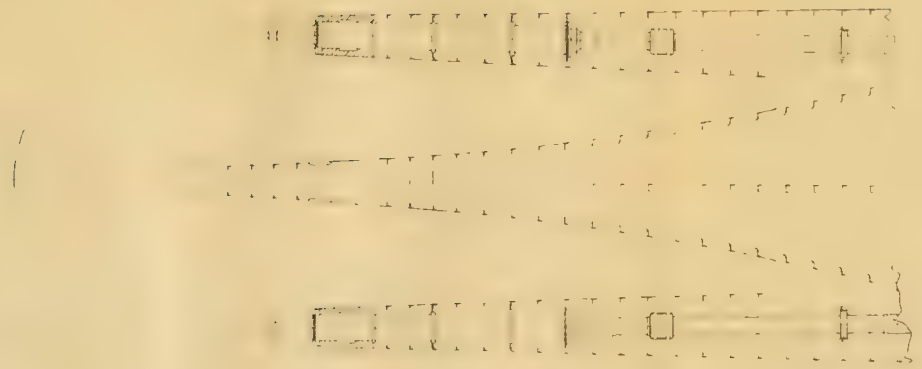
To illustrate paper on "Machinery and Trials of the Passenger Ships—American Legion Class," by Robert Warriner, Esq., Member.


PROJECTED AREA
DEVELOPED AREA
2-⅜" PIPE TAP & DRILL FOR AIR VENT, PLUG AFTER FILLING WITH TALLOW.
PIPE TAP - TO BE PLUGGED AFTER FILLING CAP WITH TALLOW
6-1⅛" Ø HOLES SPOTFACE 2½" DIA
1" TAPPED HOLE FOR EYE BOLT, FIT PLUG.
FILL WITH ROMAN CEMENT
1" U S S TAPPED HOLE FOR LIFTING BOLT
END VIEW OF CAP
SECTION "A-A"
2-⅜" PIPE TAP & DRILL PUMP FULL OF TALLOW
LOOKING FORD.
DETAIL OF BOSS "B"
PIPE TAP FOR BOSS
DETAIL OF PIPE TAP ON CAP AT "C"
3 U S S TAPPED HOLES 3¾" DEEP FOR EYE BOLT, FIT PLUG.
2-2½" U S S TAP FOR 2" JACKING BOLTS ON A 20" D P C DIAMETRICALLY OPPOSITE

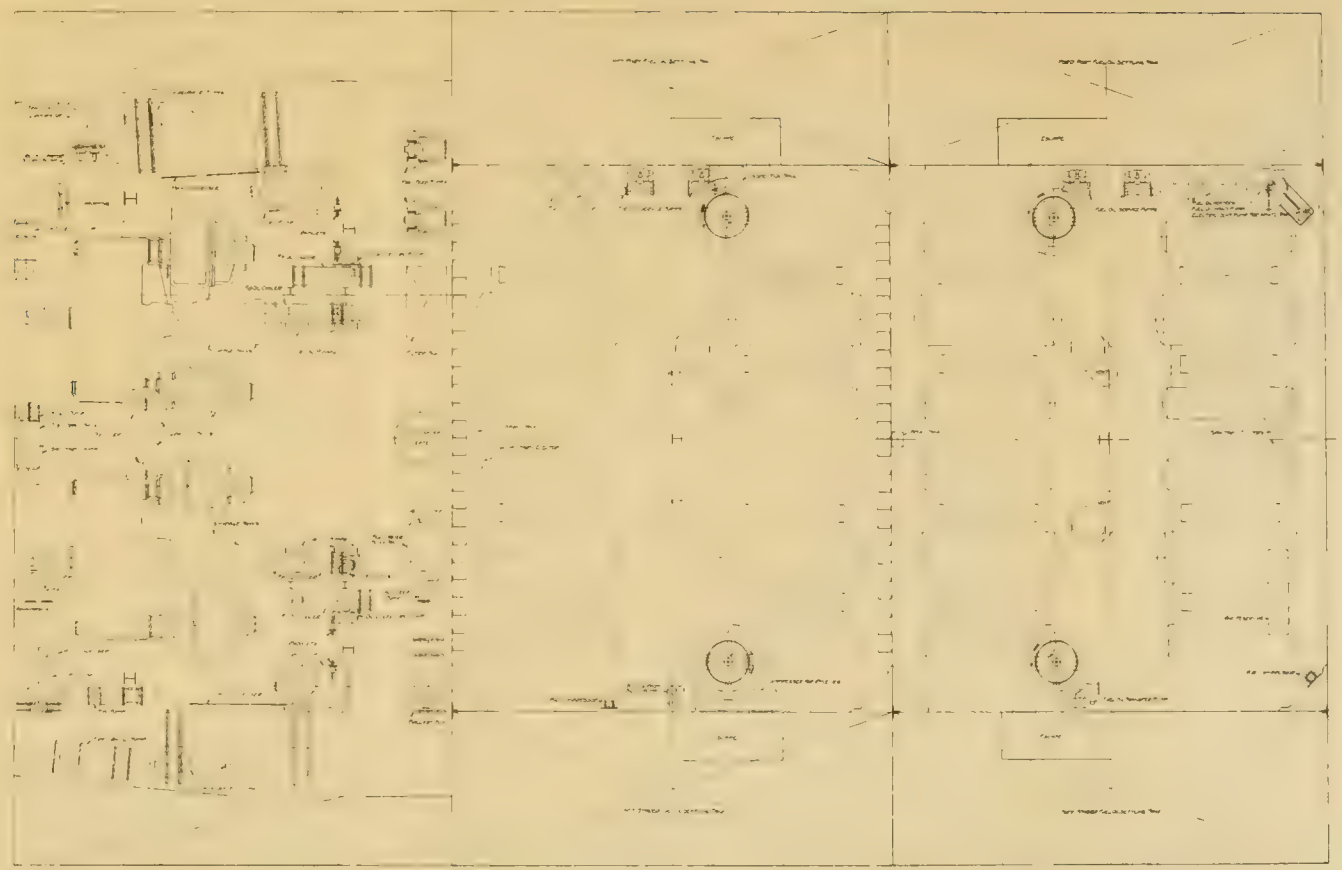
PROPELLER FOR S.S. PRESIDENT PIERCE

Data	
DIAMETER	16'-6"
PITCH	17'-0"
PROJECTED AREA	69.6 ☐'
PROJECTED AREA RATIO	.325
DEVELOPED	80.7 ☐'
SHAFT HORSE POWER	12000 (TOTAL)
REVS PER MIN	32
NUMBER OF BLADES	3

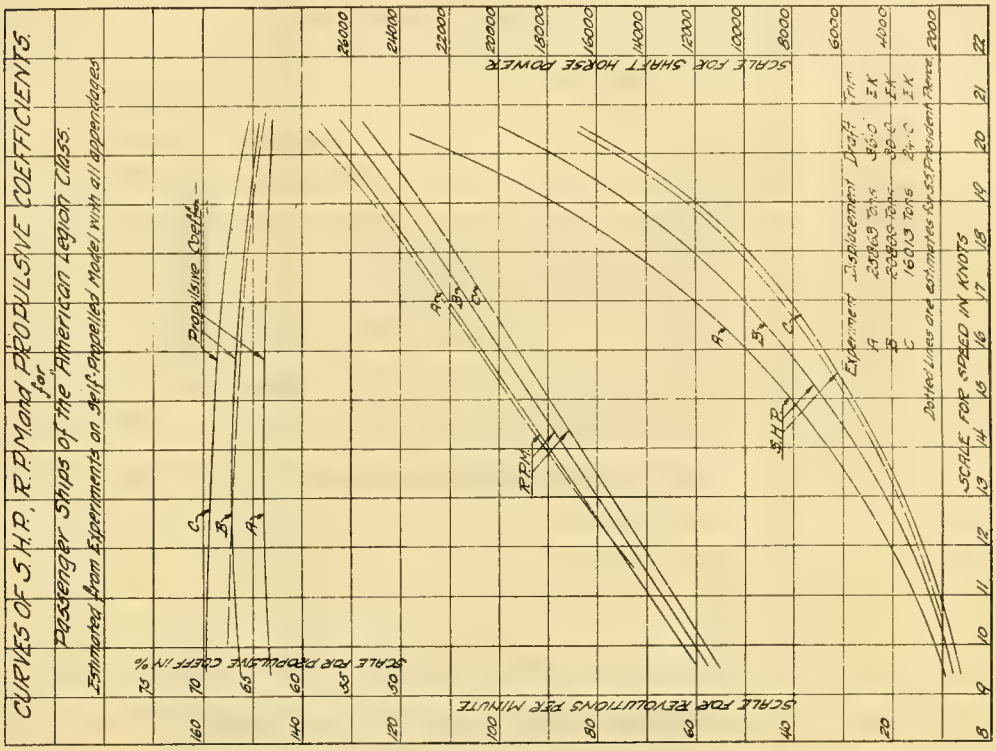
To illustrate paper on "Machinery and Trials of the Passenger Ships—American Legion Class," by Robert Warriner, Esq., Member.

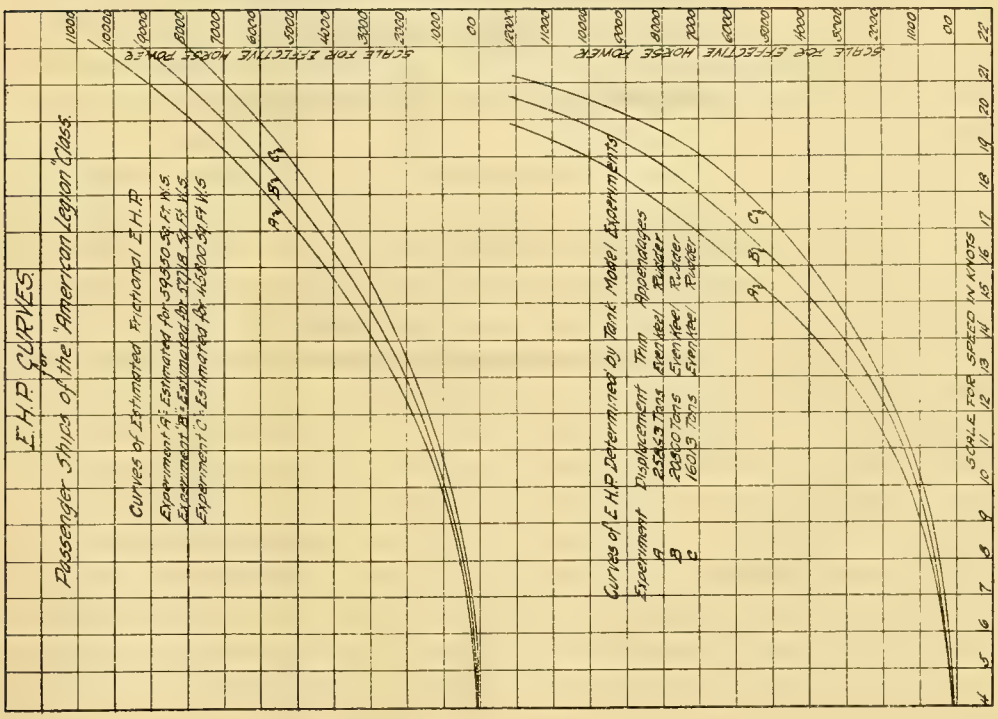


PLAN VIEW OF
REPEAT OF MACHINERY AND PROPELLERS
S.S. PRESIDENT PIERCE



To illustrate paper on "Machinery and Trials of the Passenger Ships—American Legion Class," by Robert Warriner, Esq., Member.


CURVES OF S.H.P., R.P.M. and PROPULSIVE COEFFICIENTS
for
Passenger Ships of the "American Legion" Class.
Estimated from Experiments on Self-propelled Model with all appendages
Propulsive Coeffs.
SCALE FOR PROPULSIVE COEFF IN %
SCALE FOR REVOLUTIONS PER MINUTE
SCALE FOR SHAFT HORSE POWER
SCALE FOR SPEED IN KNOTS
Experiment Displacement Draft
A 23363 Tons 34'-0" F.K.
B 23360 Tons 30'-2" F.K.
C 16013 Tons 24'-0" F.K.
Dotted lines are estimates for S.S. Pleasure Vessel


E.H.P. CURVES
for
Passenger Ships of the "American Legion" Class.
Curves of Estimated Frictional E.H.P.
Experiment A: Estimated for 23363 Tons 34'-0" M.S.
Experiment B: Estimated for 23218 Tons 30'-2" M.S.
Experiment C: Estimated for 16013 Tons 24'-0" M.S.
SCALE FOR EFFECTIVE HORSE POWER
SCALE FOR SPEED IN KNOTS
Curves of E.H.P. Determined by Tank Model Experiments
Experiment Displacement Trim Appendages
A 23363 Tons Even Keel Rudder
B 23360 Tons Even Keel Rudder
C 16013 Tons Even Keel Rudder

To illustrate paper on "Machinery and Trials of the Passenger Ships—American Legion Class," by Robert Warriner, Esq., Member.

RESULTS FROM TRIALS OF S.S. PRESIDENT PIERCE

ECONOMY TRIALS.

ENGINE ROOM.

Speed in Knots	Propeller R.P.M. Starb	Propeller R.P.M. Port	Shaft Horse Power Starb	Shaft Horse Power Port	Steam Consumption Starb. Turbine Lbs. per H.P. per Hr.	Steam Consumption Starb. Turbine Lbs. per S.H.P.	Pressures Main Steam	Pressures Auxiliary Steam	Pressures Reducing and Exhaust Main Feed Pump Disch.
18.8	125.2	124.6	16525	16518	14.895	10.70	244.1	240.8	16.5
16.8	111.6	110.0	14980	14990	13.349	11.22	250.2	246.8	15.6
15.4	102.1	101.3	13490	13620	11.502	11.89	252.2	244.6	16.4
	103.5	102.3	14715	14840	12.819	12.74	251.0	244.3	14.7
	93.0	96.0	27110	25.00					

Port Turbine Nozzles Open	Pressures H.P. Chest	Pressures 2nd Stage Inlet	Pressures L.P. Chest	Pressures Exhaust (Ins. Hg.)	Temperature H.P. Chest	Temperature Exhaust	Lubricating Oil Discharge Temp. Fwd. H.P. Bearing	Lubricating Oil Discharge Temp. Aft H.P. Bearing	Lubricating Oil Discharge Temp. Thrust Bearing	Lubricating Oil Discharge Temp. Fwd. L.P. Bearing	Lubricating Oil Discharge Temp. Aft L.P. Bearing
14	240.5	109.0	67.4	28.8	404.7	100.8	116.2	116.7	105.2	113.9	118.9
11	240.8	54.4	27.8	28.8	403.6	99.3	108.3	114.0	99.4	108.1	116.2
8	247.6	60.4	0.4	29.2	410.6	91.5	107.9	112.0	100.4	106.5	117.8
	263.6	74.0	0.5	29.5	408.7						

Starboard Turbine Nozzles Open	Pressures H.P. Chest	Pressures 2nd Stage Inlet	Pressures L.P. Chest	Pressures Exhaust (Ins. Hg.)	Temperature H.P. Chest	Temperature Exhaust	Lubricating Oil Discharge Temp. Fwd. H.P. Bearing	Lubricating Oil Discharge Temp. Aft H.P. Bearing	Lubricating Oil Discharge Temp. Thrust Bearing	Lubricating Oil Discharge Temp. Fwd. L.P. Bearing	Lubricating Oil Discharge Temp. Aft L.P. Bearing
14	236.8	97.9	47.1	28.3	400.2	88.7	113.8	113.0	102.3	115.7	126.0
11	246.0	74.0	0.0	28.8	402.0	91.3	117.9	116.4	102.2	113.8	128.9
8	248.6	32.0	4.7	28.8	402.4	88.4	110.6	122.0	100.4	109.0	111.5
	247.0	65.7	26.0	28.8	402.0						

Auxiliary Pressures Starboard Circ. Water to Coolers	Lub. Oil to Cooler	Lub. Oil to Bearings	Steam to Pumps	Auxiliary Pressures Port Circ. Water to Coolers	Lub. Oil to Coolers	Lub. Oil to Bearings	Steam to Pumps
5.4	21.0	13.1	228.5	5.7	18.6	13.5	220.9
5.6	20.0	13.2	228.0	5.0	18.4	13.5	220.0

Temperatures Starboard Main Injection	Temperatures Starboard Fan Room	Temperatures Starboard Engine Room	Temperatures Starboard Condenser	Temperatures Port Main Injection	Temperatures Port Fan Room	Temperatures Port Engine Room	Temperatures Port Condenser	Temperatures Port Reid Gas Burners	Temperatures Port Reid Gas Filter Chamber	Temperatures Engine Room
41.8	66.2	38.0	44.9	70.3	69.0	19.25	79.2	25.8	24.1	16.4
40.2	67.1	39.1	40.3	72.1	65.1	12.31	75.0	25.2	22.3	13.8
36.4	62.4	42.5	36.4	63.3	50.5	11.88	73.4	24.3	22.5	0

Pump Strokes D.S.P.M. Lub. Oil Pump Starboard	Lub. Oil Pump Port	Main Recip. Feed Pumps Combined	Main Recip. Feed Pumps Each
25.8	24.1	16.4	8.5
25.2	22.3	13.8	7.7
24.3	22.5	0	14.5

FORWARD BOILER ROOM

No. of Boilers in Use	Air Pressure "W.G.	Steam Pressure No. 1 Boiler	Steam Pressure No. 2 Boiler	Steam Pressure No. 3 Boiler	Steam Pressure No. 4 Boiler	Steam Temperature No. 1 Boiler	Steam Temperature No. 2 Boiler	Steam Temperature No. 3 Boiler	Steam Temperature No. 4 Boiler	Size of Burners	No. of Burners in Use No. 1 Boiler	No. of Burners in Use No. 2 Boiler	No. of Burners in Use No. 3 Boiler	No. of Burners in Use No. 4 Boiler	Fuel Oil Pressure No. 1 Boiler	Fuel Oil Pressure No. 2 Boiler	Fuel Oil Pressure No. 3 Boiler	Fuel Oil Pressure No. 4 Boiler	Temperatures Fuel Oil to Burners	Temperature of Room
4	2.5	263.7	264.9	264.4	261.0	444.6	433.3	439.8	433.3	5/32"	40	48	49	30	234.0	235.2	234.9	233.6	182.5	116.7
4	2.9	265.0	268.8	269.8	269.4	453.3	452.2	449.3	444.3	5/32"	39	39	41	40	211.1	211.7	208.8	213.3	182.0	116.6
4	3.0	262.4	261.3	268.0	262.1	451.3	451.2	451.3	451.3	5/32"	29	38	41	34	210.0	210.6	210.8	208.8	171.5	118.3

AFT BOILER ROOM

No. of Boilers in Use	Air Pressure "W.G.	Steam Pressure No. 5 Boiler	Steam Pressure No. 6 Boiler	Steam Pressure No. 7 Boiler	Steam Pressure No. 8 Boiler	Steam Temperature No. 5 Boiler	Steam Temperature No. 6 Boiler	Steam Temperature No. 7 Boiler	Steam Temperature No. 8 Boiler	Size of Burners	No. of Burners in Use No. 5 Boiler	No. of Burners in Use No. 6 Boiler	No. of Burners in Use No. 7 Boiler	No. of Burners in Use No. 8 Boiler	Fuel Oil Pressure No. 5 Boiler	Fuel Oil Pressure No. 6 Boiler	Fuel Oil Pressure No. 7 Boiler	Fuel Oil Pressure No. 8 Boiler	Temperature Fuel Oil to Burners	Temperature of Room
4	.37	260.7	260.0	260.9	258.9	438.1	440.4	434.2	434.3	3/32"	30	30	30	30	227.0	231.7	220.0	226.3	165.8	104.7
4	.39	259.6	255.7	259.6	259.0	445.1	441.7	445.0	435.0	3/32"	39	42	43	41	201.7	194.4	201.9	201.7	174.6	113.7
4	.37	258.6	255.9	260.1	257.5	430.7	442.5	442.5	435.0	3/32"	29	30	23	30	205.6	207.5	205.6	211.3	166.9	118.8

FLATS AND GRATINGS

Generator Output Volts	Amperes Portable	Amperes Aft	Refrigerating Plant Temperatures Ice Machine Cond. Inl.	Ice Machine Cond. Out.	Tank Water at Bottom	Brine Inlet	Brine Outlet	Refrigerating Plant Temperatures Brine	Ice Machine Suction	Ice Machine Discharge	Steam to Ice Machine	Refrigerating Plant Pressures Exh. Front Ice Machine
111.5	33.47	32.99	45.0	52.5	46.2	14.3	10.6	15.6	23.75	70.83	13.05	13.1
111.4	29.50	28.33	42.2	45.9	44.8	21.6	18.0	14.1	14.61	45.38	10.43	14.6
111.6	30.20	27.50	38.0	44.6	39.8	30.9	24.1	11.3	34.63	63.50	9.60	14.3

STANDARDIZATION TRIAL

Run	Knots	R.P.M. Starb	R.P.M. Port	R.P.M. Ave.	S.H.P. Starb	S.H.P. Port	S.H.P. Total
1	13.46	78.7	78.2	78.5	1651	1734	3385
2	11.20	82.6	81.6	82.1	1618	1742	3360
3	13.36	79.0	79.2	79.1	1644	1676	3320
AVE	12.91	80.1	80.1	80.4	1608	1728	3336
4	13.30	95.7	92.9	95.5	2732	23134	6586
5	13.25	90.6	90.8	90.7	2560	2662	5222
6	13.44	92.5	92.3	92.4	2848	2768	5616
AVE	14.3	93.1	93.0	93.1	2675	2791	5406
7	13.75	106.9	106.4	106.6	3930	4127	8057
8	13.46	108.2	108.2	108.2	4000	4200	8205
9	10.50	105.5	105.1	105.3	4118	4120	8238
AVE	16.07	107.2	107.0	107.1	4014	4162	8176
10	13.65	126.0	124.8	125.4	6440	6365	12775
11	19.05	124.5	124.4	124.5	6685	6670	13355
12	19.21	126.3	126.0	126.2	6685	6647	13332
AVE	19.00	125.3	124.9	125.1	6656	6588	13244
14	19.76	126.0	124.4	125.5	6702	6344	13046
15	18.05	125.3	125.1	125.3	6685	6980	13665
16	19.41	126.2	124.5	125.4	6580	6540	13120
AVE	18.86	126.0	124.8	125.4	6663	6641	13304

Run	Steam Pressures Main Steam	H.P. Steam Chest Starb	H.P. Steam Chest Port	H.P. Steam Chest Ave.	2nd Stage Starb	2nd Stage Port	2nd Stage Ave.	L.P. Steam Chest Starb	L.P. Steam Chest Port	L.P. Steam Chest Ave.	Exhaust Starb	Exhaust Port	Exhaust Ave.	Temperature °F H.P. Steam Chest Starb	Temperature °F H.P. Steam Chest Port	Temperature °F H.P. Steam Chest Ave.	Nozzles Open Starb	Nozzles Open Port	Nozzles Open Ave.
1																			
2																			
3																			
AVE	245	243	237.3	238.8	249	250	249	168	118	143	28.77	29.4	29.59	399	365	362	8	8	8
4																			
5																			
6																			
AVE	247	194.7	196.3	195.5	37.0	40.0	38.5	11.0	6.0	8.5	29.70	29.85	29.78	385	395	390	8	8	8
7																			
8																			
9																			
AVE	25.4	200.7	200.3	200.5	55.0	63.0	59.0	1.6	0.0	0.8	29.43	29.08	29.25	391	397	394	11	11	11
10																			
11																			
12																			
AVE	24.9	241.0	239.7	239.4	94.0	101.3	97.6	5.0	7.8	6.4	28.63	28.90	28.76	404	409	407	14	14	14
14																			
15																			
16																			
AVE	24.9	248.0	244.0	244.0	98.0	103.7	101.9	5.7	8.2	7.0	28.50	28.82	28.66	403	406	405	14	14	14

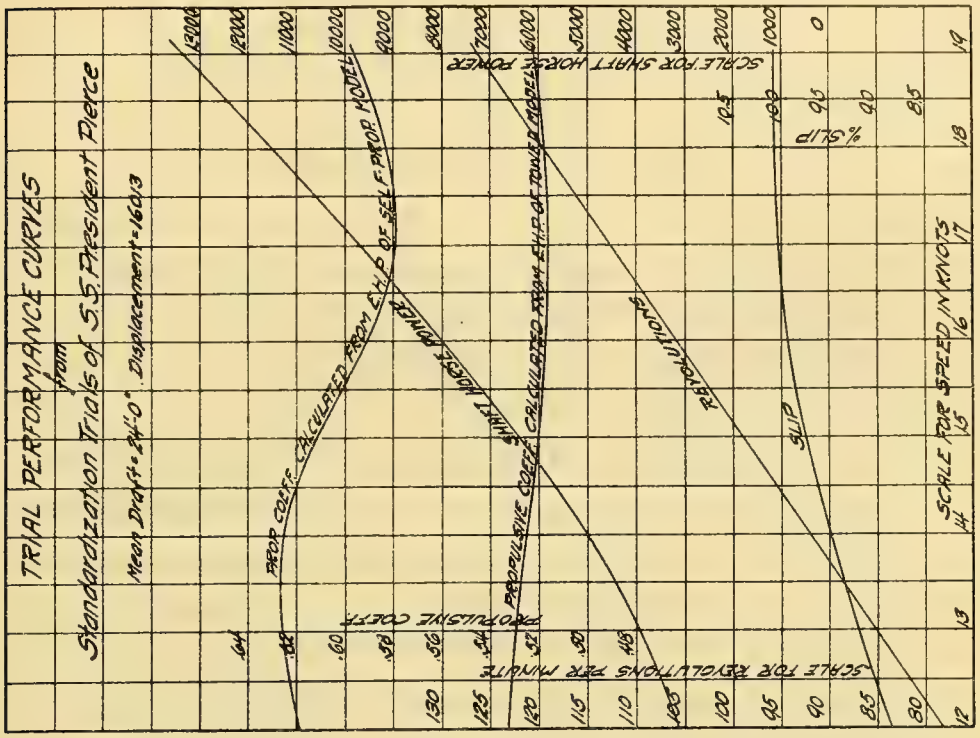
Unless otherwise marked all pressures are in pounds gauge and all temperature are in degrees fahrenheit.

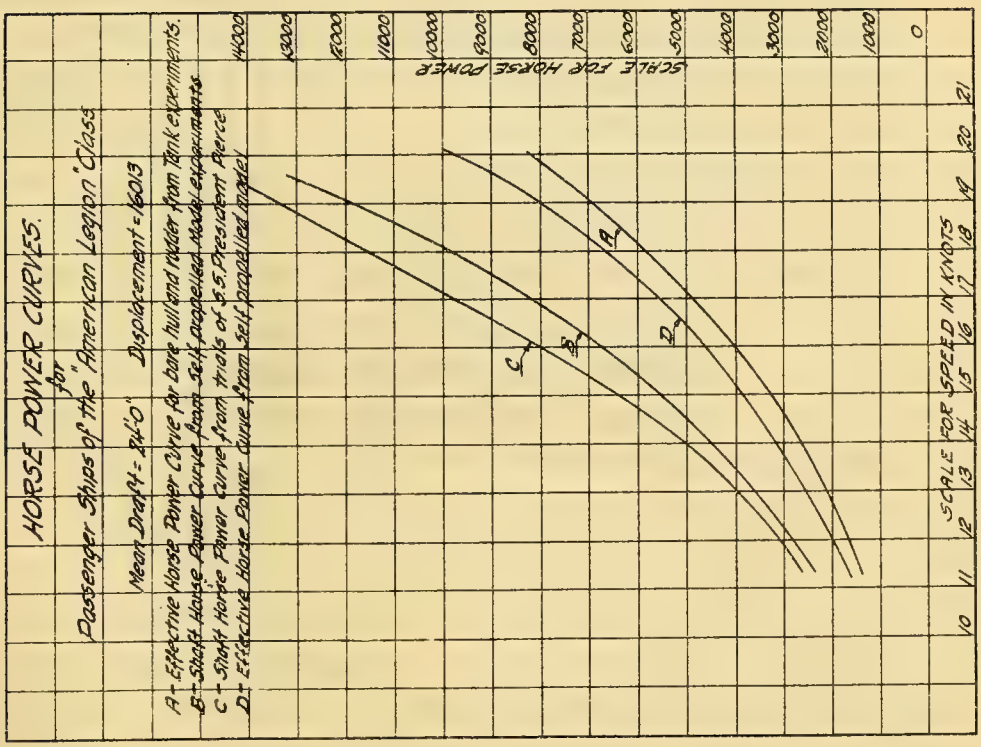
Barometer = 30.62".

Mean Draft during trials = 24'-0".

Mean Displacement during trial = 16013 Tons.

To illustrate paper on "Machinery and Trials of the Passenger Ships—American Legion Class," by Robert Warriner, Esq., Member.


TRIAL PERFORMANCE CURVES
from
Standardization Trials of S.S. President Pierce
Mean Draft = 24'0". Displacement = 16013
PROP COEFF. CALCULATED FROM E.H.P. OF SELF PROP MODEL
SHAFT HORSE POWER
PROPULSIVE COEFF. CALCULATED FROM E.H.P. OF TOWED MODEL
REVOLUTIONS
SLIP
SCALE FOR REVOLUTIONS PER MINUTE
PROPULSIVE COEFF.
SCALE FOR SHAFT HORSE POWER
% SLIP
SCALE FOR SPEED IN KNOTS


HORSE POWER CURVES.
for
Passenger Ships of the "American Legion" Class
Mean Draft = 24'0" Displacement = 16013
A = Effective Horse Power Curve for bare hull and rudder from Tank experiments.
B = Shaft Horse Power Curve from self propelled Model experiments.
C = Shaft Horse Power Curve from trials of S.S. President Pierce
D = Effective Horse Power Curve from self propelled Model
SCALE FOR HORSE POWER
SCALE FOR SPEED IN KNOTS

To illustrate paper on "Machinery and Trials of the Passenger Ships—American Legion Class," by Robert Warriner, Esq., Member.

S.S. PRESIDENT McKINLEY.
RESULTS FROM STANDARIZATION AND ECONOMY TRIALS

ENGINE ROOM

Run	Speed in Knots	Propeller R.P.M. Starb	Propeller R.P.M. Port	Propeller R.P.M. Ave	Shaft Horse Power Starb	Shaft Horse Power Port	Shaft Horse Power Total	Fuel Oil Consumption Lbs per Hour	Fuel Oil Consumption Lbs per S.H.P.	Pressures Main Steam	Pressures Auxiliary Steam	Pressures Auxiliary Exhaust	Pressures Main Feed Pump Disch
Average of Standardization Runs 1,2 & 3	12.3	83.64	82.67	83.15	1676	1310	2986			248	172	12	290
Average of Standardization Runs 4,5 & 6	15.207	105.4	104.4	104.72	3304	3027	6331			258	178	8	290
Average of Standardization Runs 7,8 & 9	16.666	116.31	116.04	116.17	4497	4289	8786			252	175	8	310
Average of Standardization Runs 10,11 & 12	18.225	126.31	126.14	126.23	5737	5633	11370			256	174	14	
Economy Trial, Average Conditions: 6.30 PM to 5.30 AM	17.38	120.87	120.94	120.90	5306	5207	10513	12200	1.16	253	169	14	320
Average Conditions for ½ Hour at Max Power	17.70	123.1	123.2	123.15	5590	5322	10912	12500	1.14	252	185	17	325

Run	Port Turbine Nozzles Open	Pressures H.P. Chest	Pressures L.P. Chest	Pressures Exhaust (Ins Hg)	Temp H.P. Chest	Temp Exhaust	Lub Oil Discharge Temp. Ford H.P. Bearing	Aft H.P. Bearing	Thrust Bearing	Ford L.P. Bearing	Aft L.P. Bearing
Runs 1,2 & 3	10	121	10"	280	467	102	126	120	95	118	120
Runs 4,5 & 6	10	211	0	27.9	470	104	118	120	100	120	116
Runs 7,8 & 9	12	233	3	27.8	479	108	118	116	98	120	120
Runs 10,11 & 12	14	234	7	27.5	468	111	120	128	100	124	124
Economy Trial	14	218	6.2	27.45	470	112.6	119	120	97	119	121
½ Hour at Max Power	14	220	7	27.6	475	112	120	120	98	117	121

Run	Starboard Turbine Nozzles Open	Pressures H.P. Chest	Pressures L.P. Chest	Pressures Exhaust (Ins Hg)	Temp H.P. Chest	Temp Exhaust	Lub Oil Discharge Temp. Ford H.P. Bearing	Aft H.P. Bearing	Thrust Bearing	Ford L.P. Bearing	Aft L.P. Bearing
Runs 1,2 & 3	10	120	14"	28.3	447	95	116	140	90	109	118
Runs 4,5 & 6	10	207	5"	281	450	100	117	135	100	113	121
Runs 7,8 & 9	12	218	2	280	465	103	119	140	100	114	122
Runs 10,11 & 12	14	218	7	27.65	453	108	120	140	100	117	129
Economy Trial	14	199	5.6	27.81	455	107	117	138	96	114	124
½ Hour at Max Power	14	200	6	27.8	460	105	118	140	96	115	124

Run	Aux. Pressures Starboard: Cir. Water to Oil Cooler	Lub Oil at Board	Lub Oil to Gears	Steam to Radoj. [?]	Aux. Pressures Port: Cir. Water to Oil Cooler	Lub Oil at Board	Lub Oil to Gears	Steam to Radoj. [?]
Runs 1,2 & 3	7	12	14.0	135	5	12	13.0	100
Runs 4,5 & 6	6	12	12.5	135	4	12	13.7	213
Runs 7,8 & 9	7	12	12.5	135	4	12	13.5	215
Runs 10,11 & 12	7	12	12.5	135	4	12	135	140
Economy Trial	6.1	12	13.2	136	3.4	12	12.6	167
½ Hour at Max Power	6	12	14.0	138	4	12	12.5	135

Run	Temperatures Starboard: Main Injection	Overbd Discharge	Condensate	Temperatures Port: Main Injection	Overbd Discharge	Condensate	Feed and Filter Tk	Pump Strokes-D.S.P.M. Lub Oil Pump Starb.	Lub Oil Pump Port	Main Feed Pump Outbd	Main Feed Pump Inbd
Runs 1,2 & 3	59	67	82	59	71	88	168	7.5	5.5	10	0
Runs 4,5 & 6	58	71	90	58	73	90	136	10	10.5	6	6
Runs 7,8 & 9	58	77	92	58	81	93	130	10	10	5	8
Runs 10,11 & 12	59	77	98	59	81	100	140	8.5	8.5	10	10
Economy Trial	65	75	94	55	78	98	129	8.6	9.2	6.8	7.1
½ Hour at Max Power	56	76	96	56	80	100	129	10	10	12	0

FORWARD BOILER ROOM

Trial	No. of Boilers in Use	Air Pressure "H₂O	Steam Pressure No. 1 Boiler	No. 2 Boiler	No. 3 Boiler	No. 4 Boiler	Steam Temperature No. 1 Boiler	No. 2 Boiler	No. 3 Boiler	No. 4 Boiler	Size of Burners	No. of Burners in Use No. 1 Boiler	No. 2 Boiler	No. 3 Boiler	No. 4 Boiler	Fuel Oil Pressure No. 1 Boiler	No. 2 Boiler	No. 3 Boiler	No. 4 Boiler	Temperature of Fuel Oil to Burner	Temp of Room
Economy Trial, Average Conditions 6.30 PM to 5.30 AM	4	.95	250	250	250	250	476	484	473	498	53-20	7	7	7	7	232	232	232	232	75	98
Average Conditions for ½ Hour at Max Power	4	1.0	250	252	250	252	470	492	460	502	53-20	7	7	7	7	260	260	260	260	76	92

AFT BOILER ROOM. / GENERATORS

Trial	No. of Boilers in Use	Air Pressure "H₂O	Steam Pressure No. 5 Boiler	No. 6 Boiler	No. 7 Boiler	No. 8 Boiler	Steam Temperature No. 5 Boiler	No. 6 Boiler	No. 7 Boiler	No. 8 Boiler	Size of Burners	No. of Burners in Use No. 5 Boiler	No. 6 Boiler	No. 7 Boiler	No. 8 Boiler	Fuel Oil Pressure No. 5 Boiler	No. 6 Boiler	No. 7 Boiler	No. 8 Boiler	Temperature of Fuel Oil to Burner	Temp. of Room	Generators: No. Gen. Running	Amperes	Volts
Economy Trial, Average Conditions 6.30 PM to 5.30 AM	4	1.15	251	251	251	251	477	466	470	478	53-20	7	7	7	7	238	238	238	238	77	94	2	707	116
Average Conditions for ½ Hour at Max Power	4	1.02	251	251	251	251	470	470	475	485	53-20	7	7	7	7	230	230	230	230	77	94	2	750	116

Barometer	29.82"
Mean Draft - Standardization Trial	21' 10 5/16"
Mean Draft - Economy Trial	21' 8¾
Displacement - Standardization Trial	14280 Tons
Displacement - Ecomony Trial	14184 Tons

NOTE.
Unles otherwise marked all pressures are in pounds gauge and all temperatures are in degrees Fahrenheit.

PROPELLER DATA.

Diameter =	16'-6",	Projected Area =	72.61 ☐'
Pitch =	16'-3",	Developed Area =	81.63 ☐'
No. of Blades =	3,	Projected Area Ratio =	.34
Designed R.P.M. =	125,	Designed S.H.P. =	6000

To illustrate paper on "Machinery and Trials of the Passenger Ships—American Legion Class," by Robert Warriner, Esq., Member.

S.S. AMERICAN LEGION

RESULTS FROM STANDARDIZATION AND ECONOMY TRIALS.

ENGINE ROOM.

Speed in Knots	Propeller R.P.M. Starb.	Propeller R.P.M. Port	Propeller R.P.M. Ave.	Shaft Horse Power Starb.	Shaft Horse Power Port	Shaft Horse Power Total	Oil Consumption Lbs. per Hour	Oil Consumption Lbs. per S.H.P.	Pressures Main Steam	Pressures Auxiliary Exhaust	Pressures Main Feed Pump Disch.	Port Turbine Nozzles Open	Port Turbine Pressures H.P. Chest	Port Turbine Pressures L.P. Chest	Port Turbine Pressures Exhaust (Ins. Hg.)	Port Turbine Temp. H.P. Chest	Port Turbine Temp. Exhaust	Port Lub. Oil Discharge Temp. Fo'd H.P. Bearing	Port Lub. Oil Discharge Temp. Aft H.P. Bearing	Port Lub. Oil Discharge Temp. Fo'd L.P. Bearing	Port Lub. Oil Discharge Temp. Aft L.P. Bearing
Average of Standardization Runs 1, 2 & 3																					
11.862	69.99	70.28	71.13	1372	1442	2814	7590	2.7	266	10	350	10	105	8.6	28.5	404	99	98	112	104	108
Average of Standardization Runs 4, 5 & 6																					
14.641	88.52	89.22	88.87	2707	2920	5627	8800	1.6	266.5	10	350	10	18.2	2.6	28.0	432	102	104	114	108	110
Average of Standardization Runs 7, 8 & 9																					
16.897	103.82	103.74	103.78	4416	4680	9096	11700	1.3	263.5	9.8	350	12	223	48	28.0	445	103	108	122	113	116
Average of Standardization Runs 10, 11 & 12																					
18.540	114.09	113.53	113.81	5877	6249	12126	13400	1.1	265	7	350	14	242	66	27.75	450	106	114	129	118	121
Economy Trials — Average Conditions: 6 P.M. to 6 A.M.																					
18.23	111.81	112.36	112.08	5670	6186	11856	12780	1.08	261.5	11.3	382	14	244	67	28.02	442	105	114	126	121	119
Average Conditions for ½ Hour at Max. Power																					
18.43	112.8	113.3	113.05	5710	6325	12035	13150	1.09	264	12.5	385	14	244	69	28.25	442	102	112	128	126	118

Speed in Knots	Starboard Turbine Nozzles Open	Starboard Turbine Pressures H.P. Chest	Starboard Turbine Pressures L.P. Chest	Starboard Turbine Pressures Exhaust (Ins. Hg.)	Starboard Turbine Temp. H.P. Chest	Starboard Turbine Temp. Exhaust	Stbd. Lub. Oil Discharge Temp. Fo'd H.P. Bearing	Stbd. Lub. Oil Discharge Temp. Aft H.P. Bearing	Stbd. Lub. Oil Discharge Temp. Fo'd L.P. Bearing	Stbd. Lub. Oil Discharge Temp. Aft L.P. Bearing	Auxiliary Pressures Circ. Water to Starb. Oil Cooler	Auxiliary Pressures Circ. Water to Port Oil Cooler	Auxiliary Pressures Lub. Oil to Cooler	Auxiliary Pressures Lub. Oil from Cool.	Temperatures Starboard Main Injection	Temperatures Starboard Main Ov'bd Discharge	Temperatures Starboard Condensate	Temperatures Port Main Injection	Temperatures Port Main Ov'bd Discharge	Temperatures Port Condensate	Temperatures Room	Temperatures Feed and Filter Tank	Temperatures Feed Water	Pump Strokes—D.S.P.M. Lub. Oil Pump Star.	Pump Strokes—D.S.P.M. Lub. Oil Pump Port	Pump Strokes—D.S.P.M. Main Feed Pump Outb'd	Pump Strokes—D.S.P.M. Main Feed Pump Inb'd
Average of Standardization Runs 1, 2 & 3																											
11.862	10	102	8.3	28.4	413	100	106	107	108	108	6.0	6.5	40	15	70	78	78	70	80	78	105	162	210	30	22	10	22
Average of Standardization Runs 4, 5 & 6																											
14.641	10	18.5	2.3	28.23	445	102	106	110	110	112	5.5	6.0	40	15	70	80	78	70	82	80	103	143	210	29	23	8	16
Average of Standardization Runs 7, 8 & 9																											
16.897	12	228	42	27.93	462	106	110	116	116	116	5.0	6.0	40	15	70	84	86	70	88	85	103	145	205	32	22	8	14
Average of Standardization Runs 10, 11 & 12																											
18.540	14	244	59	27.78	460	108	112	117	115	117	5.0	5.8	40	15	70	90	88	70	92	88	107	128	184	33	24	8	18
Economy Trials — Average Conditions: 6 P.M. to 6 A.M.																											
18.23	14	244	59	27.74	451	108	119	122	124	122	5.3	5.6	39.5	13	72	92	91	72	92	92	103	134	195	28	25	9	11.5
Average Conditions for ½ Hour at Max. Power																											
18.43	14	245	60	27.75	450	108	118	120	125	125	5.5	5.6	40	15	71	90	89	71	89	91	102	134	197	28	27	8	12

FORWARD BOILER ROOM

Trial	No. of Boilers in Use	Air Pressure "H₂O"	Steam Pressure No. 1 Boiler	Steam Pressure No. 2 Boiler	Steam Pressure No. 3 Boiler	Steam Pressure No. 4 Boiler	Steam Temperature No. 1 Boiler	Steam Temperature No. 2 Boiler	Steam Temperature No. 3 Boiler	Steam Temperature No. 4 Boiler	Size of Burners	No. of Burners in Use No. 1 Boiler	No. of Burners in Use No. 2 Boiler	No. of Burners in Use No. 3 Boiler	No. of Burners in Use No. 4 Boiler	Fuel Oil Press.	Temperature of Fuel Oil to Burners	Temp. of Room
Economy Trial — Average Conditions: 6 P.M. to 6 A.M.	4	1.2	260	260	260	260	538	533	538	505	52-20	7	7	7	7	197	116	128
Average Conditions for ½ Hour at Max. Power	4	1.5	260	260	260	260	530	530	530	500	52-20	7	7	7	7	195	117	130

AFT BOILER ROOM — GENERATORS

Trial	No. of Boilers in Use	Air Pressure "H₂O"	Steam Pressure No. 5 Boiler	Steam Pressure No. 6 Boiler	Steam Pressure No. 7 Boiler	Steam Pressure No. 8 Boiler	Steam Temperature No. 5 Boiler	Steam Temperature No. 6 Boiler	Steam Temperature No. 7 Boiler	Steam Temperature No. 8 Boiler	Size of Burners	No. of Burners in Use No. 5 Boiler	No. of Burners in Use No. 6 Boiler	No. of Burners in Use No. 7 Boiler	No. of Burners in Use No. 8 Boiler	Fuel Oil Press.	Temperature of Fuel Oil to Burners	Temp. of Room	Generators No. Running	Generators Amperes	Generators Volts
Economy Trial — Average Conditions: 6 P.M. to 6 A.M.	4	1.19	260	260	260	260	498	487	496	482	52-20	7	7	7	7	200	98	134	2	758	114
Average Conditions for ½ Hour at Max. Power	4	1.5	260	260	260	260	495	475	495	475	52-20	7	7	7	7	195	99	138	2	770	114

BAROMETER = 29.95"
MEAN DRAFT - STANDARDIZATION TRIAL = 21'- 4⅝"
MEAN DRAFT - ECONOMY TRIAL = 21'- 3¾"
DISPLACEMENT - STANDARDIZATION TRIAL = 13888 TONS
DISPLACEMENT - ECONOMY TRIAL = 13817 TONS

NOTE:
UNLES OTHERWISE MARKED ALL PRESSURES ARE IN POUNDS GAUGE AND ALL TEMPERATURES ARE IN DEGREES FAHRENHEIT.

PROPELLER DATA.

DIAMETER =	17'-0"	PROJECTED AREA =	71.499 ⊄
PITCH =	18'-6"	DEVELOPED AREA =	84.4 ⊄
NO. OF BLADES =	3	PROJECTED AREA RATIO =	.315
DESIGNED R.P.M. =	110	DESIGNED S.H.P. =	6000
	BUILT UP.		

To illustrate discussion by Charles F. Bailey, Esq., Member of Council, on paper entitled "Machinery and Trials of the Passenger Ships—American Legion Class," by Robert Warriner, Esq., Member.

TRIAL PERFORMANCE OF PASSENGER SHIPS OF AMERICAN LEGION CLASS.

TRIAL	FULL POWER					INTERMEDIATE POWER				LOW POWER			
SHIP	President Cleveland	President Jackson	President Pierce	President McKinley	American Legion	President Cleveland	President Pierce	President McKinley	American Legion	President Cleveland	President Pierce	President McKinley	American Legion
BUILDER	N.N.S.&D.D.Co.	N.N.S.&D.D.Co.	Bethlehem	N.Y.S.Corp	N.Y.S. Corp.								
DISPLACEMENT ON TRIALS	About 14,000	13,900	16,013	14,184	13,817	About 14,000	16,013	14,184	13,888	14,000	16,013	14,184	13,888
PROPELLER, DEV. AREA, DIAM. & PITCH	80.7 16'-6" x 17'-0"	80.7 16'-6" x 17'-0"	80.7 16'-6" x 17'-0"	81.63 16'-6" x 16'-3"	84.4 17'-0" x 18'-6"								
DESIGNED R.P.M. AT FULL POWER	125	125	125	125	110								
AVG R.P.M. ON TRIAL	119.15	120.45	124.9	120.9	112.8	109.8	110.8	116.18	103.78	95.1	101.7	104.9	88.87
SPEED	①	①	18.8	17.38	18.23	①	16.8	16.666	16.897	①	15.4	15.207	14.641
S.H.P.	12,500	13,050 ②	13,043	10513	11,856	9,335	9,930	8,786	9,096	6,175	7110	6331	5627
TURBINES	New York News Curtis	New York News Curtis	Bethlehem Curtis	Bethlehem Curtis	West'h. ⑦ DBL Flow								
MAIN STEAM PRESSURE - GAUGE	247	250	249.1	253	261.5	250	250.2	252	263.5	251	252	258	266.5
H.P. CHEST PRESSURE - GAUGE	233	229	238.7	209	244	242	243.3	225	225	167	248	209	183
" " TEMPERATURE °F	461	464	403.5	464	457	462	403	472	453	455	406 5	460	438
" - SUPERHEAT °F	61	69	0	72	53	59	0	75	56	81	0	68	57
" FIRST STAGE PRESSURE - GAUGE	93.5	86	103.5			67	80.2			43	56.2		
L.P. CHEST PRESSURE - GAUGE	12.1	13.2	5.72	5.9	63	5.4	1.5	2.5	45.0	1.5"	2"	2.5"	24.5
CONDENSER VACUUM - INS.	28.33"	28.6"	28.6"	27.63"	27.88"	28.58"	28.8"	27.9"	27.96"	29.08"	29"	28"	28.11"
TEMPERATURE OF L.P. EXHAUST - °F	84	90	94.7	110	106.5	77.5	95.3	105.5	104.5	70.5	90	102	102
TEMPERATURE MAIN INJECTION - °F	44	54	41.8	55	72	44	40.2	58	70	43	36.4	58	70
" OVERBD DISCHARGE - °F	70	79	68.2	77	92	67	79.6	79	86	60	63	72	81
" AIR PUMP " - °F	78	85	60.8	96	91.5	75	62.1	92.5	85.5	67	46.5	90	79
TYPE OF BOILERS & TOTAL HEATING SURF.	B & W. ③ 41,376	B & W. ③ 41,376	Yarrow 40,000 ⑤	Yarrow 40,000 ⑤	B & W. ③ 41,376								
No. OF BOILERS IN USE	8	8	8	8	8	6	8			4	8		
" " BURNERS " "	54	52	39	56	56	36	32			28	25		
AVERAGE BOILER PRESSURE - GAUGE	258	258	261	250.5	260	256	260			253	259		
MAIN FEED TEMPERATURE - °F	198	201	212.9		195	203	221.9		205	213	225.4		210
FIRE ROOM " - °F	80	85	113	94	131	79	115			78	119		
" " AIR PRESSURE - INS. H_2O	.60"	.75"	3.1"	1.05"	1.2"	.68"	3.4"			.85"	3.35"		
PRESS. OIL TO BURNERS - GAUGE	148	207	228	235	198.5	111	214			154	208		
TEMP. " " " - °F	169	125	173	76	107	159	184			153	164		
" OF STACK - °F	483	468				475				465			
ACT. EVAP. PER LB. OIL	13.60					13.30				13.37			
EQUIV. " " " " F&A 212°	14.81					14.63				14.60			
LBS. OIL PER # H.S. PER HR.	.293	.298				.326				.346			
LBS. WATER PER S.H.P. HR. - TURBS.	10.54 ⑤		10.7 ④			10.78 ⑤	11.22 ④			11.97 ⑤	11.89 ④		
LBS. WATER PER S.H.P. HR. - TURBS. CORR. TO 230 CHEST PR.; 75° SUPHT. & 2" ABS	10.65					11.12				11.52			
LBS. WATER PER S.H.P. HR. - AUX.	2.46 ⑤		2.74			2.27 ⑤				2.78 ⑤			
" OIL " " " - ACTUAL	.954 ⑥	.940 ⑥		1.16	1.08	1.06 ⑥			1.3	1.13 ⑥			1.6
" " " " - CORR. TO 19000 B.T.U.	.935	.941				1.044				1.12			

① No STANDARDIZATION TRIALS.

② From "Pres. Cleveland's" S.H.P. - R.P.M. curve.

⑦ Three turbines, H.P. & I.P. on one pinion and L.P. on other pinion.

③ B&W. Superheaters - 4160 # - Total

④ Foster type superheaters - 5000 # Total

⑤ Water measured in calibrated tanks.

⑥ Water measured for one set of turbines only.

⑤ Obtained by diff. of total W.R. & W.R. Turbs only.

Total water meas. for short period only

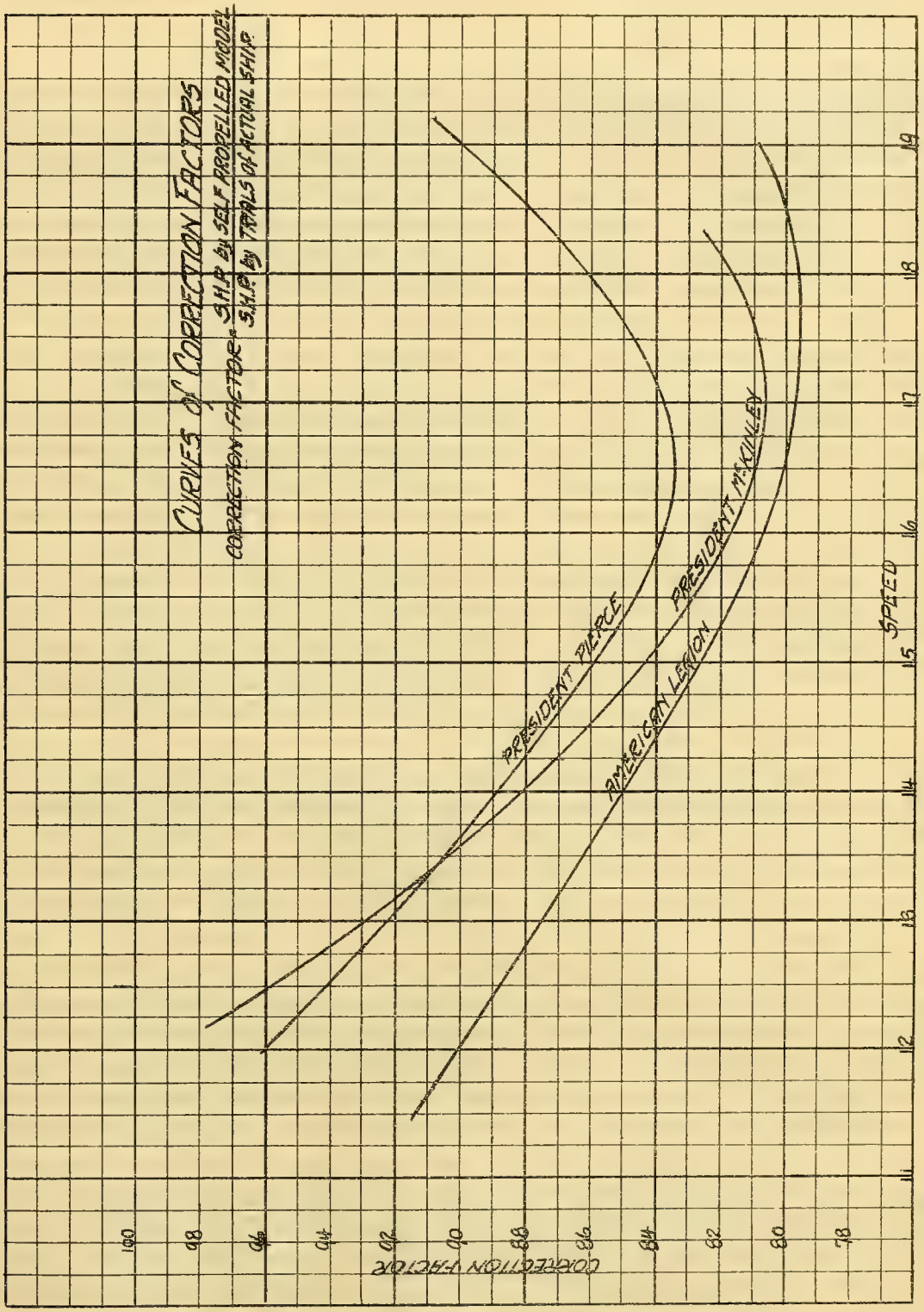
⑥ Oil meas. by calibrated meters.

TSH. 11-6-22

DATA FOR BETH. & N.Y.S. SHIPS FROM MR. WARRINER'S PAPER BEFORE N.A. 11/9/22

N.N.S. & D.D. Co. ENG. DEPT.; EST. DIV.

To illustrate reply by Mr. Warriner to discussion by Admiral C. W. Dyson, U. S. N., Member of Council, on paper entitled "Machinery and Trials of the Passenger Ships—American Legion Class," by Robert Warriner, Esq., Member.



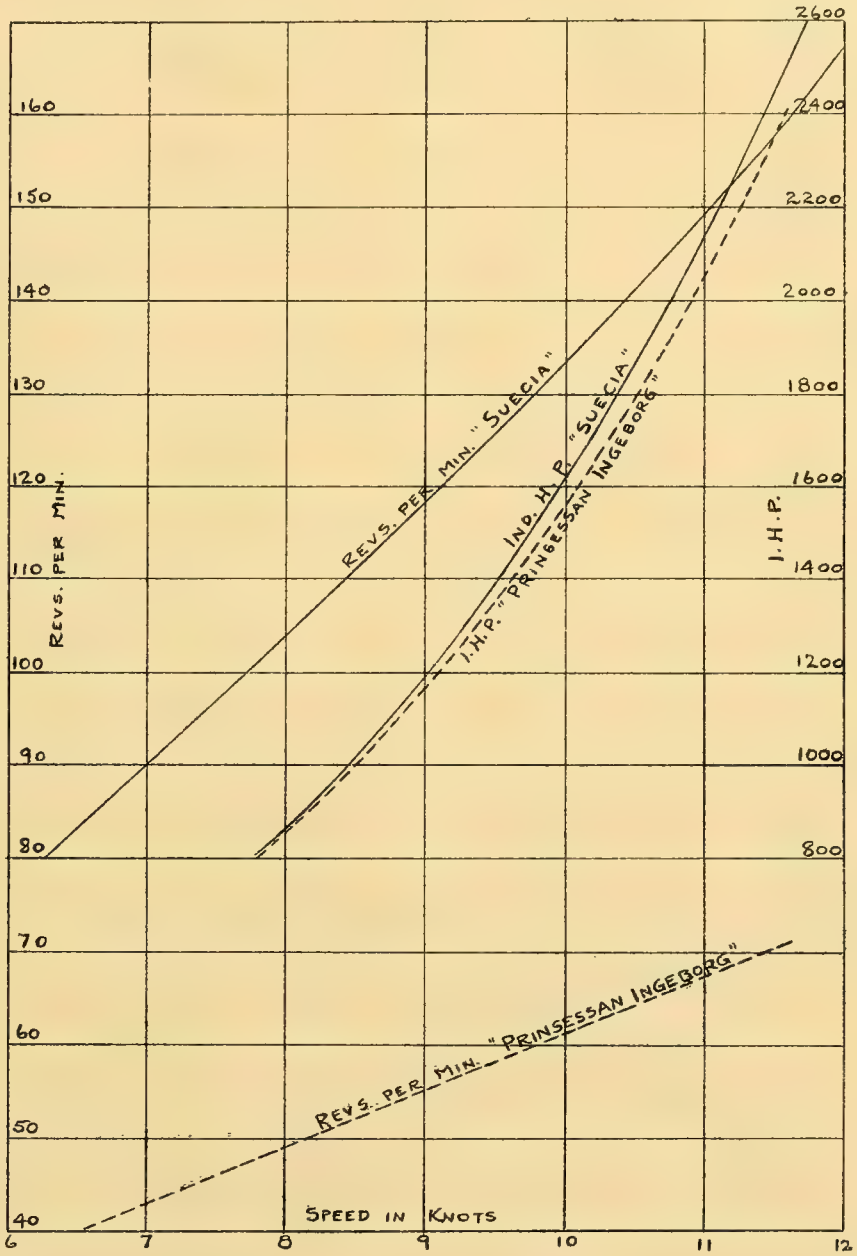
To illustrate paper on "Selection of the Best Kind of Propelling Machinery," by James L. Ackerson, Esq., Member.

TYPE OF SHIP		MACHINERY: TYPE	MACHINERY: WEIGHT	MACHINERY: INITIAL COST	COST OF FUEL AT SEA PER DAY	COST OF FUEL PER YEAR: 200 DAYS AT SEA	COST OF FUEL PER YEAR: IN PORT	COST OF FUEL PER YEAR: TOTAL	COST OF OPERATING PERSONNEL	DEPRECIATION CHARGES 15%	TOTAL COST PER ANNUM	FEED WATER MAKE UP PER DAY	FUEL OIL REQUIRED FOR FOLLOWING DISTANCES ALLOWING 15% MARGIN: 5,000 M.	10,000 M.	15,000 M.	20,000 M.	INNER BOTTOM TANK CAPACITY	CARGO SPACE TAKEN UP FOR FUEL OIL FOR FOLLOWING DISTANCES: 5,000 M.	10,000 M.	15,000 M.	20,000 M.
10,000 TON FREIGHTER 10 KNOTS SINGLE SCREW	1500 S.H.P.	R.E. & S.B.	380 TON	$167,000	22 TON $220.00	$44,000	$1,650	$45,650	$13,920	$25,111	$84,570	6 TON	440 TON	880 TON	1,320 TON	1,760 TON	680 TON	0	200 TON	640 TON	1,080 TON
		R.E. & W.T.B.	316 TON	$163,000	22 TON $220.00	$44,000	$1,650	$45,650	$13,920	$24,500	$84,070	6 TON	440 TON	880 TON	1,320 TON	1,760 TON	ABOVE FEED WATER	0	200 TON	640 TON	1,080 TON
		G.T. & S.B.	355 TON	$175,750	22 TON $220.00	$44,000	$1,650	$45,650	$13,920	$26,400	$85,970	6 TON	440 TON	880 TON	1,320 TON	1,760 TON	REQUIREMENT	0	200 TON	640 TON	1,080 TON
		G.T. & W.T.B.	291 TON	$171,000	22 TON $220.00	$44,000	$1,650	$45,650	$13,920	$25,600	$85,170	6 TON	440 TON	880 TON	1,320 TON	1,760 TON		0	200 TON	640 TON	1,080 TON
		4 CYCLE DIESEL	400 TON	$207,000	7½ TON $84.00	$16,800	$495	$17,295	$12,360	$31,000	$60,655	0	145 TON	290 TON	435 TON	580 TON		0	0	0	0
		2 CYCLE DIESEL	350 TON	$222,000	7½ TON $84.00	$16,800	$495	$17,295	$12,360	$32,200	$62,855	0	145 TON	290 TON	435 TON	580 TON		0	0	0	0
12,000 TON FREIGHTER 11 KNOTS TWIN SCREW	2500 S.H.P.	R.E. & S.B.	625 TON	$239,000	34 TON $340.00	$68,000	$1,650	$69,650	$14,280	$34,500	$118,430	8 TON	650 TON	1,300 TON	1,950 TON	2,600 TON	1,038 TON	0	262 TON	912 TON	1,562 TON
		R.E. & W.T.B.	538 TON	$224,000	34 TON $340.00	$68,000	$1,650	$69,650	$14,280	$33,600	$117,530	8 TON	650 TON	1,300 TON	1,950 TON	2,600 TON	ABOVE FEED WATER REQUIREMENT	0	262 TON	912 TON	1,562 TON
		G.T. & S.B.	570 TON	$244,000	34 TON $340.00	$68,000	$1,650	$69,650	$14,280	$36,600	$120,530	8 TON	650 TON	1,300 TON	1,950 TON	2,600 TON		0	262 TON	912 TON	1,562 TON
		G.T. & W.T.B.	483 TON	$239,000	34 TON $340.00	$68,000	$1,650	$69,650	$14,280	$35,800	$119,730	8 TON	650 TON	1,300 TON	1,950 TON	2,600 TON		0	262 TON	912 TON	1,562 TON
		4 CYCLE DIESEL	650 TON	$307,000	11 TON $130.00	$26,000	$490	$26,490	$12,720	$46,000	$85,210	0	210 TON	420 TON	630 TON	840 TON		0	0	0	0
		2 CYCLE DIESEL	580 TON	$327,000	11 TON $130.00	$26,000	$490	$26,490	$12,720	$49,000	$88,210	0	210 TON	420 TON	630 TON	840 TON		0	0	0	0
10,000 TON FREIGHTER 12 KNOTS TWIN SCREW	2500 S.H.P.	R.E. & S.B.	625 TON	$230,000	34 TON $340.00	$68,000	$1,650	$69,650	$14,280	$34,500	$118,430	8 TON	680 TON	1,360 TON	2040 TON	2,720 TON	1,140 TON	0	220 TON	900 TON	1,580 TON
		R.E. & W.T.B.	538 TON	$224,000	34 TON $340.00	$68,000	$1,650	$69,650	$14,280	$33,600	$117,530	8 TON	680 TON	1,360 TON	2,040 TON	2,720 TON	ABOVE FEED WATER REQUIREMENT	0	220 TON	900 TON	1,580 TON
		G.T. & S.B.	570 TON	$244,000	34 TON $340.00	$68,000	$1,650	$69,650	$14,280	$36,600	$120,530	8 TON	680 TON	1,360 TON	2,040 TON	2,720 TON		0	220 TON	900 TON	1,580 TON
		G.T. & W.T.B.	483 TON	$239,000	34 TON $340.00	$68,000	$1,650	$69,650	$14,280	$35,800	$119,730	8 TON	680 TON	1,360 TON	2,040 TON	2,720 TON		0	220 TON	900 TON	1,580 TON
		4 CYCLE DIESEL	650 TON	$307,000	11 TON $130.00	$26,000	$490	$26,490	$12,720	$46,000	$85,210	0	220 TON	440 TON	660 TON	880 TON		0	0	0	0
		2 CYCLE DIESEL	540 TON	$327,000	11 TON $130.00	$26,000	$490	$26,490	$12,720	$49,000	$88,210	0	220 TON	440 TON	660 TON	880 TON		0	0	0	0
10,000 TON FREIGHTER 12 KNOTS SINGLE SCREW	3000 S.H.P.	R.E. & S.B.	910 TON	$363,000	57 TON $570.00	$114,000	$3,300	$117,300	$14,640	$37,500	$186,440	12 TON	910 TON	1,820 TON	2,730 TON	3,640 TON	1,040 TON	0	730 TON	1,640 TON	2,550 TON
		R.E. & W.T.B.	750 TON	$352,000	57 TON $570.00	$114,000	$3,300	$117,300	$14,640	$53,500	$185,440	12 TON	910 TON	1,820 TON	2,730 TON	3,640 TON	ABOVE FEED WATER REQUIREMENT	0	730 TON	1,640 TON	2,550 TON
		G.T. & S.B.	780 TON	$346,000	47 TON $470.00	$94,000	$3,300	$97,300	$14,640	$52,000	$163,940	12 TON	760 TON	1,520 TON	2,280 TON	3,040 TON		0	430 TON	1,190 TON	1,950 TON
		G.T. & W.T.B.	620 TON	$336,000	47 TON $470.00	$94,000	$3,300	$97,300	$14,640	$50,500	$162,440	12 TON	760 TON	1,520 TON	2,280 TON	3,040 TON		0	430 TON	1,190 TON	1,950 TON
		4 CYCLE DIESEL	900 TON	$524,000	15 TON $173.00	$33,611	$495	$34,095	$16,140	$78,600	$128,835	0	256 TON	512 TON	768 TON	1,024 TON		0	0	0	0
		2 CYCLE DIESEL	800 TON	$547,000	15 TON $173.00	$33,611	$495	$34,095	$16,140	$82,200	$132,435	0	256 TON	512 TON	768 TON	1,024 TON		0	0	0	0
10,000 TON TANKER 11 KNOTS TWIN SCREW	2500 S.H.P.	R.E. & S.B.	587 TON	$237,000	34 TON $340.00	$102,000	$650	$102,650	$14,280	$35,500	$152,430	8 TON	650 TON	1,300 TON	1,950 TON	2,600 TON	ALL TANKS NOT REQUIRED FOR FEED WATER COULD BE USED FOR CARGO OIL	650 TON	1,300 TON	1,950 TON	2,600 TON
		R.E. & W.T.B.	500 TON	$228,000	34 TON $340.00	$102,000	$650	$102,650	$14,280	$34,200	$151,130	8 TON	650 TON	1,300 TON	1,950 TON	2,600 TON		650 TON	1,300 TON	1,950 TON	2,600 TON
		G.T. & S.B.	532 TON	$253,000	34 TON $340.00	$102,000	$650	$102,650	$14,280	$38,000	$154,930	8 TON	650 TON	1,300 TON	1,950 TON	2,600 TON		650 TON	1,300 TON	1,950 TON	2,600 TON
		G.T. & W.T.B.	445 TON	$246,000	34 TON $340.00	$102,000	$650	$102,650	$14,280	$37,000	$153,930	8 TON	650 TON	1,300 TON	1,950 TON	2,600 TON		650 TON	1,300 TON	1,950 TON	2,600 TON
		4 CYCLE DIESEL	653 TON	$339,000	11 TON $130.00	$39,000	$195	$39,195	$12,720	$49,500	$101,415	0	210 TON	420 TON	630 TON	840 TON		210 TON	420 TON	630 TON	840 TON
		2 CYCLE DIESEL	545 TON	$352,000	11 TON $130.00	$39,000	$195	$39,195	$12,720	$52,600	$104,455	0	210 TON	420 TON	630 TON	840 TON		210 TON	420 TON	630 TON	840 TON
17,000 TON PASSENGER STEAMER 17 KNOTS TWIN SCREW	22000 S.H.P.	R.E. & S.B.	1700 TON	$720,000	98 TON $940.00	$188,000	$3300	$191,300	$32,940	$108,000	$332,240	16 TON	1,300 TON	2,600 TON	3,900 TON	5,200 TON	1,200 TON	100 TON	1,400 TON	2,700 TON	4,000 TON
		R.E. & W.T.B.	1400 TON	$700,000	98 TON $940.00	$188,000	$3300	$191,300	$32,940	$105,000	$329,240	16 TON	1,300 TON	2,600 TON	3,900 TON	5,200 TON	ABOVE FEED WATER REQUIREMENT	100 TON	1,400 TON	2,700 TON	4,000 TON
		G.T. & S.B.	1440 TON	$580,000	77 TON $770.00	$154,000	$3300	$157,300	$32,940	$97,000	$277,240	16 TON	1,075 TON	2,150 TON	3,225 TON	4,300 TON		0	950 TON	2,025 TON	3,100 TON
		G.T. & W.T.B.	1140 TON	$560,000	77 TON $770.00	$154,000	$3300	$157,300	$32,940	$94,000	$274,240	16 TON	1,075 TON	2,150 TON	3,225 TON	4,300 TON		0	950 TON	2,025 TON	3,100 TON
		4 CYCLE DIESEL	1840 TON	$800,000	31 TON $360.00	$72,000	$495	$72,495	$27,000	$120,000	$219,495	0	435 TON	870 TON	1,305 TON	1,740 TON		0	0	105 TON	540 TON
		2 CYCLE DIESEL	1510 TON	$855,000	31 TON $360.00	$72,000	$495	$72,495	$27,000	$128,000	$227,495	0	435 TON	870 TON	1,305 TON	1,740 TON		0	0	105 TON	540 TON

R.E., RECIPROCATING ENGINE
G.T., GEARED TURBINES

S.B., SCOTCH BOILERS
W.T.B, WATER TUBE BOILERS

To illustrate discussion by J. C. Shaw, Esq., Member, on paper entitled "Selection of the Best Kind of Propelling Machinery," by James L. Ackerson, Esq., Member.



MS "SUECIA" - DISP. 9625 T, LENGTH 362'-0" BEAM 51'-3" DRAUGHT 23'-1½"

SS "PRINSESSAN INGEBORG" LENGTH 360'-0" BEAM 48'-9" DRAUGHT 21'-10"
DISP. 8660

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